

# The Financial Accelerator and Countercyclical Interest Margins

*Evidence from Norwegian Data*

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Data

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# Summary

This thesis, though twofold, focuses on the financial accelerator, procyclical credit and the counter cyclical of banks' interest margins. All analysis and data transformations were undertaken in either Oxmetrics (PcGive) or Excel.

The first part of the thesis looks at the financial accelerator mechanism in the Norwegian economy through a reconstruction of the work of Hammersland and Jacobsen (2008). In this section, I estimate a Structural Vector Error Correction Model (SVECM) of the simultaneous relationships between asset prices, production and credit, using the original methodology and sample period of Hammersland and Jacobsen's paper. The methodology used differs from other, more mainstream, methods in that it identifies the structural equations of the model through so-called structural dummies, influencing only one of the equations each. In following this method, I found it to be somewhat unstable and the battle to get to the final structure was hard-fought. In the end, the evidence from this reconstruction gives reason for second-guessing the results of Hammersland and Jacobsen. Nonetheless, and even with less significant results, it is hard to discard the possibility of the existence of a financial accelerator working in the Norwegian economy. Though these results are interesting in themselves, this part of the thesis should also serve as a remark on the lack of reproduction and validation of economic work.

In the second part of the thesis, the focus is shifted over to one of the key mechanism in the financial accelerator framework of Bernanke, Gilchrist and Gertler (1999), namely banks' interest margins. Following the theory in their paper, the interest margin of banks should show sign of countercyclical movements, enhancing the reinforcing mechanism of the financial accelerator.

I start this section of by operationalizing my own measure of the interest margin. In this, I use the average lending rate of banks and develop, through a weighted average cost of capital approach, a measure for banks' funding cost, including the costs of deposits, wholesale funding and capital. The interest margin is defined as the difference between these measures.

I later find that the development of this margin as well as the development in the net interest margins, defined as net interest income over total interest earning assets, shows signs of non-stationary negative movements from the beginning of the 1990's until today. This however,

in light of historical events and general developments in the banking market, not surprising. Specifically, I point at higher quality in credit analyses, capital regulations, more competition and higher productivity, as possible explanations.

Having thoroughly discussed and analyzed the developments in the interest margin, I turn focus to the cyclical behavior of the measure. First, I analyze at the correlation between the interest margin and the output gap, unemployment rate and the number of bankruptcies, which are all highly cyclical variables. This analysis shows that there are clear and significant sign of counter cyclicity in the interest margin.

Secondly, to get a more holistic view and be able to look at some dynamics, I specify an econometric model through a Robust OLS method. In this analysis, I separate the funding cost and the average lending rate to get a more realistic model, where the funding cost follows the business cycle, while the lending rate follows the funding cost. The final Vector Error Correction Model shows that the banks' funding cost (as defined in this thesis) can be considered procyclical. Moreover, the lending rate, which follows the movements in the funding cost, will typically change with less than the funding cost, linking us back to the countercyclical movements of the interest margin. At the end, different long-term cyclical effects of the margin are also considered.

Assuming a negative connection between the margin and bank lending, the result gives support to the use of banking regulation as means for dampening the procyclical movements in credit and the financial accelerator effects. Specifically, the results can be connected to the newly introduced countercyclical buffer, and its goal of creating a more stable financial system.

# Preface

The topic of this thesis took form due to my desire to combine and learn more about three general fields of interests; banking, econometrics and monetary policy. However, as the paper took shape, themes from many other subject from my time at the *University of Oslo* were also covered.

As this thesis marks the end of a long educational journey, I would like to thank the *University of Oslo* and *Oslo and Akershus University College of Applied Sciences* for providing me with the resources needed to make it all possible.

Several individuals also deserve special thanks, starting with the most important one - my supervisor, Ragnar Nymoen. His guidance and uplifting comments turned many seemingly hard problems manageable, and kept me on the right track. I would also like to thank him for his impressive availability, patience and enthusiasm.

Secondly, I am hugely grateful to Karl Jacobsen for his thorough review of this thesis, which provided me with extremely helpful, relevant and suggestive feedback.

Furthermore, I wish to thank Roger Hammersland for providing comments to his own work and Asbjørn Rødseth for comments regarding the banks' interest margins. For providing me with the data on capital adequacy ratios, I also thank Q. Farooq Akram.

Additional thanks to the *University of Oslo* for believing in me and, on the basis of this, providing me with a scholarship to write this thesis.

Last, but not least, I would like to thank my friends and family, and especially my girlfriend Bettina Bjørtomt, for encouraging comments and for being outlets for frustration and joy as the months passed.

Finally, I would like to point out that any remaining errors or faults are mine alone.





# Table of Contents

<b>1</b>	Introduction .....	1
<b>2</b>	Theory.....	3
<b>2.1</b>	The Financial Accelerator .....	3
<b>2.2</b>	A review of the financial accelerator literature .....	4
<b>2.3</b>	Agency costs: The interest margin's connection with the financial accelerator .....	6
<b>2.3.1</b>	The moral hazard model of Holmström and Tirole (1997) and the interest rate premium in Bernanke, Gilchrist and Gertler (1999) .....	6
<b>3</b>	A reconstruction of Hammersland and Jacobsen's (2008) financial accelerator estimation.....	13
<b>4</b>	The development in the banks' interest margins.....	25
<b>4.1</b>	A definition of the Interest margin and some stylized facts.....	25
<b>4.1.1</b>	Defining a Weighted average cost of capital funding cost and an interest margin .....	25
<b>4.1.2</b>	The stylized facts about the margin.....	31
<b>5</b>	Econometric approach to interest margin modelling .....	37
<b>5.1</b>	Correlation analysis .....	37
<b>5.2</b>	Regression analysis.....	37
<b>6</b>	Results .....	40
<b>6.1</b>	Results of correlation analysis .....	40
<b>6.2</b>	Results of regression analysis.....	41
<b>7</b>	Concluding remarks.....	49
	References .....	51
	Appendix .....	54

## Figures:

<u>Figure 1</u> : The dynamic and static multiplier in Kyotaki and Moore (1997) of a negative temporary shock.....	5
<u>Figure 2</u> : The distribution of firms between no -, intermediate - and direct finance.....	11
<u>Figure 3</u> : Wholesale funding share of banks .....	26
<u>Figure 4</u> : The approximate distribution of wholesale funding in Norwegian banks as of Oct. 2012....	28
<u>Figure 5</u> : How the banks' funding cost is built up .....	30
<u>Figure 6</u> : Development of the average lending rate and the estimated funding cost.....	32
<u>Figure 7</u> : Development of the estimated interest rate margin .....	32
<u>Figure 8</u> : The markets risk premium measured as the difference between the 3 month NIBOR and the monetary policy rate.....	33
<u>Figure 9</u> : Real productivity in financial services.....	34
<u>Figure 10</u> : The estimated interest margin and the net interest margin (NIM) .....	35
<u>Figure 11</u> : Comparing the interest margin and the output gap .....	36
<u>Figure 12</u> : Actual and fitted values .....	43
<u>Figure 13</u> : Impulse responses following a negative unit shock to unemployment.....	46
<u>Figure 14</u> : Impulse responses following a permanent negative unit shock to unemployment and a permanent positive unit shock to the output gap. ....	47
<u>Figure 15</u> : Impulse responses following a permanent negative unit shock to unemployment and a permanent positive unit shock to the output gap. ....	48
<u>Figure AA.2</u> : Comparable graphics.....	55
<u>Figure AA.3</u> : Forecasts.....	57
<u>Figure AA.4</u> : Stability tests .....	58
<u>Figure AD.1</u> : Stability tests based on system in Table 6.....	62
<u>Figure AD.1.2</u> : Residuals from the estimated equations in Table 6.....	62

## Tables:

<u>Table 1</u> : Johansen's test for the number of cointegrated vectors .....	15
<u>Table 2</u> : The identified system of cointegrated linear combinations given $r=3$ , the loading matrix and test for overidentifying restrictions. ....	17
<u>Table 3</u> : The estimated system using H&J's final model specification. ....	22
<u>Table 4</u> : The estimated system using the strict structural GETS method.....	23
<u>Table 5</u> : Correlation analysis.....	40
<u>Table 6</u> : The results of estimation .....	42
<u>Table 7</u> : The results of estimation with contemporaneous unemployment .....	45
<u>Table AA.1</u> : The final structure of Hammersland and Jacobsen (2008) .....	54
<u>Table AC</u> : Unit root tests and significance of time trend in the average lending rate and the funding cost. ....	60
<u>Table AD.2</u> : The results of estimation with contemporaneous unemployment and original ECM's....	63

# 1 Introduction

The financial crisis of 2008 followed by the European debt and banking crisis, have seen many economies spiraling out of control in the last couple of years, making both the financial accelerator theory and banks' role in the economy more topical than ever. In light of this, there has been an increased focus on the reinforcing links between production, asset prices and credit - the so-called financial accelerator - in economic papers. Few however, take a deeper look at one of the key mechanism in this accelerator, namely the banks' interest margin. This thesis does.

In their 1999 paper on the financial accelerator, Bernanke, Gilchrist and Gertler pinned down the cyclicity of the banks' interest margins as the key mechanism driving the financial accelerator. It is this theory I intend to utilize in this thesis, in order to further enhance the evidence of the accelerator.

In this thesis, the focus is on the Norwegian economy. In order to establish a reference, I begin by reconstructing the evidence from one of the leading papers on the financial accelerator in Norway, Hammersland and Jacobsen's, 2008 paper. Because the results of the Hammersland and Jacobsen analysis, though slightly weakened by the results of this thesis' reconstruction, point in the direction of the existence of a financial accelerator, the remaining parts of the thesis attempts to answer how these financial accelerator effects, affects banks' interest margins and the implications this might have.

After specifying, and discussion the development of, a measure for the banks' interest margins through a weighted average cost of capital approach, I analyze the cyclicity of this measure through a correlation analysis and through the estimation of an econometric model. The main conclusion drawn from my analysis is that there are clear signs of countercyclical movements in the banks' interest margins. This supplements the evidence of Hammersland and Jacobsen in important ways and give the financial accelerator theory even more empirical relevance. Interestingly, the observed countercyclical movements in banks margin, seem to smooth banks' net interest margin, measuring the banks' marginal earnings from their available funds, over time. This increases the realism of the theory, as it provides a compelling reasoning behind the movements of the margin.

My results will also have policy implications in support of banking regulations. Specifically countercyclical interest margins are relevant in light of the newly introduced countercyclical buffer. However, as the development of the interest margin shows, other bank regulations may have had implication for the margin in the past.

The rest of the thesis is organized as follows: In Section 2, I briefly discuss some main theoretical contributions about the financial accelerator, and I review one general example of agency costs in banking, in order to motivate my thesis' focus on interest rate margins. Section 3 contains the reconstruction of the work of Hammersland and Jacobsen (2008), mapping the financial accelerator in Norway. Since the work of Hammersland and Jacobsen, does not include any interest rate relationships, the section that follows attempts to fill this gap. First, I review some stylized facts about interest margins in Norway, starting with the definition of this measure. From that starting point, I specify the basis of a correlation- and an econometric analysis of the relationship between the business cycle and the interest margin in Norway. The results of the analyses are then presented in section 6, before concluding remarks are made, regarding modelling weaknesses and policy implications, in the last section. At the very end, there is an Appendix with additional figures and tables, including a short list of the variables used in this thesis.

## 2 Theory

The theoretical and empirical base on the matter of interest rates, financial accelerator effects and agency costs is immense and can in no way be fully covered within the scope of this thesis. In this chapter, I will therefore, highly selectively, review some of the literature, while keeping the main focus on theory most relevant for the preceding chapters of the thesis. Specifically I will first explain how the financial accelerator theory came to be and then present some of the leading papers on it. Since one of the main components of the financial accelerator theory is agency costs, I will thereafter use some space to clarify the impact of agency costs, in a simple model of bank lending.

### 2.1 The Financial Accelerator

Broadly speaking, the concept of a financial accelerator, captures the idea of reinforcing effects credit markets have on business cycle fluctuations. While the term was first used by Bernanke, Gertler and Gilchrist in their 1994 paper, the recognition of such a relationship is much older. The mechanism at work is as follows: In an economic downturn, asset values drop. This lowers the value of existing and new collateral pledges to banks, and therefore increase the risks associated with lending. As a response, banks lend out less. Less credit reduces investment in real capital, which further deepens the economic downturn, and so on.

The idea about such an accelerator is not a new phenomenon, and it can be traced back to both Fisher and Keynes, as well as earlier authors<sup>1</sup> (Bernanke et al, 1999). However since the seminal paper by Modigliani and Miller (1958), and their theory on the irrelevance of a firms capital structure on its market value, the mapping of credit market impact on business cycles in macroeconomic modelling was sidetracked for several decades. However, the Modigliani-Miller theorem has always been regarded (by many) as rather unrealistic, and during the 70's, 80's and 90's (an onward), principal-agent based theory took shape, explaining how asymmetric information and moral hazard induced agency cost in financing. In contrast to the Modigliani-Miller Theorem, the introduction of agency cost, through for example risk of default, was much more realistic in explaining how the leverage ratio impact firms' market value and, furthermore, how credit market conditions connect with real economic activity.

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<sup>1</sup> Kyotaki and Moore (1997) report a line from their paper all the way back to Veblen (1904, chap. 5).

Based on this, principal-agent theory laid the grounds for what is now known as the financial accelerator in macroeconomic modelling. Having refuted some of the propositions in the Modigliani-Miller Theorem, the idea about reinforcing effects between credit markets and the real economy made a “comeback” in mainstream macroeconomic theory and modelling in the late 1980’s<sup>2</sup>. Finally, in the late 1990’s-early 2000’s models containing financial accelerator effects started being used for policy analysis around the world.

## 2.2 A review of the financial accelerator literature

One of the most influential models linking credit market inefficiencies to the real business cycle was Bernanke and Gertler (1989). They produced a neoclassical overlapping generations model linking output dynamics, borrowers net worth and lending. Through constraints on borrowing, brought on by costly state-verification-induced agency costs<sup>3</sup>, they developed a framework in which well-capitalized borrowers receive a smaller financial premium than firms with lower net worth. In response to different shocks, the economy then displays reinforcing effects through the credit channel. In their setup firms with low net worth are hit the hardest. It is hard to find any literature on the subject, written after 1989, not referring back to this specific paper.

Another widely cited paper is Kyotaki’s and Moore’s *Credit Cycles* (1997), in which they construct a dynamic model where borrowers are constrained by lenders, who cannot force borrowers to repay their debt unless it is secured. In their model, a durable asset, for example land, plays a dual role as collateral and factor of production. Land comes in a fixed total supply. There are two types of firms in their economy; one type producing using identical technology, and another type whose technology is idiosyncratic. The main result from this is that firms with random skills become credit constrained in equilibrium. Finally, when a negative shock to technology occurs, the constrained firms’ net worth decreases. Since they are constrained, they cannot increase their borrowing, and they are forced to cut back on their investment expenditure. The decrease in demand for land leads to a reduction in price in order for the market to clear, and credit becomes even tighter. In the next period they earn less due to lower investments, which again lowers their net worth, which further reduces investments in land and so on. The dynamics of the model is presented in Figure 1, which is borrowed

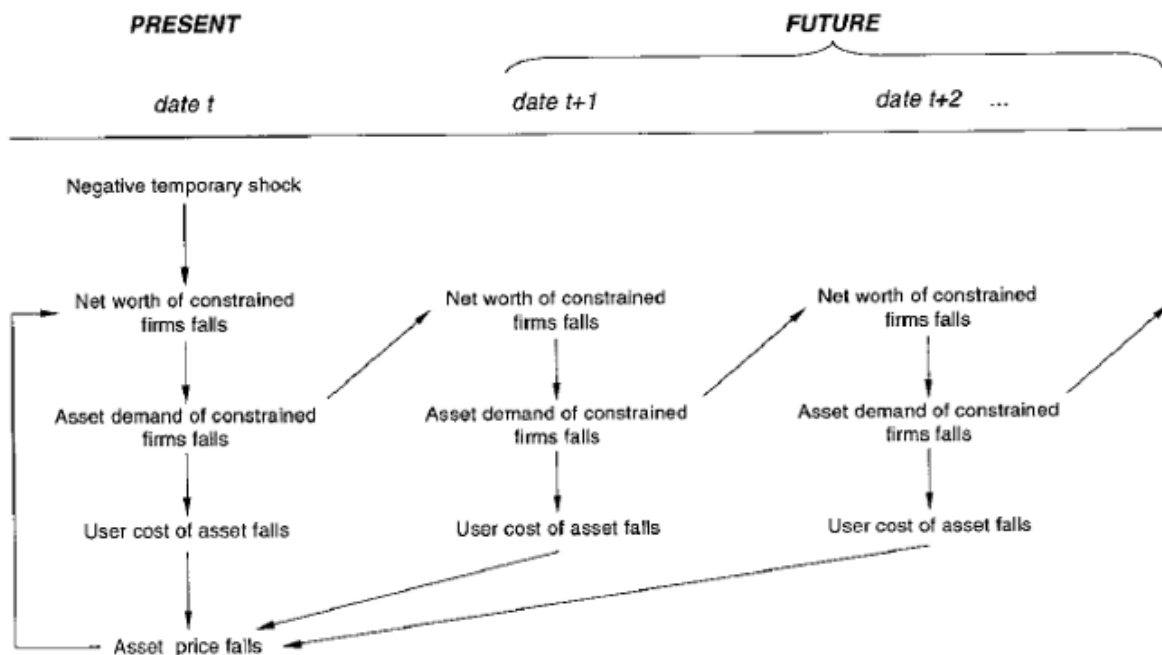
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<sup>2</sup> See for example Bernanke and Gertler (1987)

<sup>3</sup> See Townsend (1979)

from Kyotaki and Moore (1997). Though the dynamics here are similar to those in related literature, this specific graph serves as a reference in explaining the dynamics of the empirical model developed by Hammersland and Jacobsen (2008), which I replicate later in this thesis.

**Figure 1: The dynamic and static multiplier in Kyotaki and Moore (1997) of a negative temporary shock**



Bernanke, Gilchrist and Gertler's 1999 paper, is another of the most influential and cited offerings in this area of economic theory. Bernanke, Gilchrist and Gertler developed a dynamic stochastic general equilibrium model (DSGE) using the nominal rigidities of the new Keynesian framework and introduce agency costs through costly state-verification (as Bernanke and Gertler (1989)). In doing so, they managed to map the accelerator effect in a much broader sense that worked through financial premiums (interest rate margins) and have had wider implications for monetary policy analysis.

Hammersland and Jacobsen (2008), which will be referred to as H&J hereafter, used the framework presented by Kyotaki and Moore to map the financial accelerator effect in Norway. This paper is one of the most cited regarding the financial accelerator in Norway. Though the Kyotaki-Moore model bears similarities (as thing often do when they explain the same thing) with the other models mention above, there is a lack of interest rate frictions in this model. An interest rate relationship was therefore also lacking in the paper of H&J. The

authors however, also seem to think that interest rate should have a place in their model<sup>4</sup>. To better understand why, the next subchapter gives a formal introduction to agency costs in banking and the rationale behind the interest margin of banks.

## **2.3 Agency costs: The interest margin's connection with the financial accelerator**

The basis of the Modigliani-Miller theorem is a world without taxes, transaction costs, bankruptcy cost and agency costs. In this world, capital structure is irrelevant and external and internal financing serves as perfect substitutes. The realism of this is however strongly debatable, and empirically, the existence of such costs are evidently present. Especially, when looking at banks' lending rates, one expects there to be a premium, or mark-up if you will, over the banks funding cost. Take the difference between deposit rates and lending rates for households as an example. It is this premium and the risks associated with it, which effectively drives the financial accelerator in both Bernanke and Gertler (1989) and Bernanke, Gilchrist and Gertler (1999), among others.

### **2.3.1 The moral hazard model of Holmström and Tirole (1997) and the interest rate premium in Bernanke, Gilchrist and Gertler (1999)**

A model which is quite easy to follow, and which also provides an intuitive explanation of interest rate premiums, is that of Holmström & Tirole (1997). The model should serve as a motivation for how interest rates might affect aggregate credit and therefore have a role in the financial accelerator mechanism. Since the latter is even clearer in the model of Bernanke, Gilchrist and Gertler (1999), I also summarize their interest rate mechanism briefly (more details in Bernanke, Gilchrist and Gertler (1999)).

In Holmström and Tirole (1997) there is a continuum of firms with different amounts of assets  $A$ . The assets are distributed according to the cumulative distribution function  $G(A)$ . The aggregate level of firm capital in economy is  $K_f = \int A dG(A)$ .

---

<sup>4</sup> See footnote 3 on page 10 of Hammersland and Jacobsen (2008)



A strong assumption in this model is that all projects are perfectly correlated, meaning that if one fail, all fail. This assumption, however not realistic, greatly simplifies the calculations<sup>5</sup>.

Firms need to invest  $I$  and therefore would need to borrow the amount  $(I-A)$  to start the project. The cheapest way to finance the project is through investors, who otherwise would deposit their money in a bank and earn interest  $1 + i^D$ . Investors must therefore be compensated with at least this rate to be willing to invest directly in the firm.

At the end of the project, the return is either  $R$  if it succeeds or zero if it fails. The probability of failure is however dependent on whether or not the firm undertakes a private benefit opportunity or not. In this particular model the firm can choose between two private benefit opportunities, earning the firm private benefit  $B$  or  $b$ , with  $B > b$ . If either one of these opportunities are taken, the probability of success is lowered from  $p_H$  to  $p_L$  and the project will no longer be economically viable, in the sense that its expected net present value is less than zero:

$$p_H R - (1 + i^D)(I - A) > 0 > p_L R - (1 + i^D)(I - A) + B$$

The realized return of the project are divided between the Investors ( $R_i$ ) and the firm ( $R_f$ ) (that is,  $R = R_f + R_i$ ), and the share going to the firm, will depend on the private benefit options. Specifically, since the inventors only invest if the project is economically viable, the firm must be compensated with

$$p_H R_f > p_L R_f + B \quad (> \quad p_L R_f + b)$$

$$p_H(R - R_i) > p_L(R - R_i) + B$$

$$R_f \geq \frac{B}{p_H - p_L} = \frac{B}{\Delta p},$$

in order to refrain from the private benefit option. That is, the firm's stake in the return must be higher than the expected agency cost, measured in terms of the private benefit and loss in success probability.

---

<sup>5</sup> Correlation is necessary to induce risk on aggregate lending, and though perfect correlations is an extreme case, assuming it only effects calculations. In real life, some degree of correlation is realistic due to macroeconomic shock, lenders specializing in specific markets, etc. (Holmström and Tirole, 1997).

The investor would of course prefer that the firm did not choose the private benefit option at all or at least that they choose private benefit  $b$  (which would reduce the agency cost). The Investors are however not capable of/do not have the time to monitor (which would limit the private benefit options) the behavior of the firm. Knowing that the firm will choose to opt for private benefit  $B$  if  $R_f \geq \frac{B}{\Delta p}$ , the investors take this into account when they demand a return equal to or bigger than their opportunity cost (deposits at bank):

$$p_H R_i \geq (1 + i^D) I_i$$

$$p_H \left( R - \frac{B}{\Delta p} \right) \geq (1 + i^D) (I - A).$$

From this we see that a firm's initial capital,  $A$ , will have to be above a certain level if the firm is to receive investor financing. More precise, solving for  $A$ , we get:

$$I - A \leq \frac{p_H}{1 + i^D} \left( R - \frac{B}{\Delta p} \right)$$

$$A \geq \bar{A}(i^D) = I - \frac{p_H}{1 + i^D} \left( R - \frac{B}{\Delta p} \right).$$

This result states that only firms with initial capital higher than  $\bar{A}(i^D)$  will receive direct finance from investors.

Those investors who do not find it reasonable to invest directly in a firm (because the net worth is too low), will instead deposit their money in a bank. The bank, which is able to monitor (due to its size and experience) and therefore control the behavior of the firms, will then reinvest the deposits and some of its own reserve capital (so that the loans are backed by bank reserves, for example due to regulatory restrictions) in the firms, and monitor their behavior. To be able to monitor, the banks have to pay the cost<sup>6</sup>,  $c$ , while the result is that the firm can no longer choose the high private benefit option, that is,  $B$  is no longer available.

The investment and return stakes in the project will now be:

$$R = R_f + R_b + R_i$$

$$I = A + I_i + I_b.$$

---

<sup>6</sup> One does not necessarily have to think of this as a pure monitoring cost. This could also reflect transaction cost, administrative costs, etc.

The bank receives  $R_b + R_i$  if the project does not fail and pays  $R_i$  to its depositors. The banks have limited liability and are not responsible for repaying the depositors (investors) if the project fails.

Following the same logic as above, the firm can only pledge the excessive amount, over what it needs to induce good behavior, to the bank. To behave the firm will require the expected payoff:

$$p_H R_f > p_L R_f + b$$

$$R_f \geq \frac{b}{p_H - p_L} = \frac{b}{\Delta p}.$$

Where  $B$ , from the direct finance option, is substituted with  $b$ , since the high benefit project is not assessable under monitoring.

In order to be willing to monitor, banks will have to be compensated for the cost of monitoring, and require:

$$p_H R_b - c > p_L R_b$$

$$R_b \geq \frac{c}{p_H - p_L} = \frac{c}{\Delta p}.$$

This last expression reflects the cost of monitoring.

From this we see that, since banks face a cost from monitoring, they will also demand a higher rate of return than the investors. Firms who do not receive financing directly from investors, will therefore be confronted with a rate equal or higher than  $1 + i^L > 1 + i^D$  on what the capital invested by the banks<sup>7</sup>.

Taking their expected return into account, the banks will invest

$$p_H R_b \geq (1 + i^L) I_b$$

$$p_H \left( \frac{c}{\Delta p} \right) \geq (1 + i^L) I_b$$

---

<sup>7</sup> Note that the bank only receives (at least) the  $1 + i^L$  rate on its own capital,  $I_b$ , the investor capital deposited at the bank is redistributed to the firms and earn the  $1 + i^D$  rate, which is paid back to the investors.

$$I_b \leq \bar{I}_b(i^L) = \frac{p_H}{(1 + i^L)} \left( \frac{c}{\Delta p} \right),$$

of their own capital in the project.

The amount of money deposited at the bank by the investors is decided by:

$$\begin{aligned} p_H R_i &= (1 + i^D) I_i \\ p_H (R - R_f - R_b) &= p_H \left( R - \frac{b}{\Delta p} - \frac{c}{\Delta p} \right) = (1 + i^D) I_i \\ I_i &= \bar{I}_i(i^D) = \frac{p_H}{(1 + i^D)} \left( R - \frac{(b + c)}{\Delta p} \right), \end{aligned}$$

where the investors take into account the required return of both the bank and the firm.

That leaves us with the amount of firms own capital needed to get the project financed, which is now:

$$\begin{aligned} A &\geq \bar{\bar{A}}(i^D, i^L) = I - \bar{I}_b(i^L) - \bar{I}_i(i^D) \\ A &\geq \bar{\bar{A}}(i^D, i^L) = I - \frac{p_H}{(1 + i^L)} \left( \frac{c}{\Delta p} \right) - \frac{p_H}{(1 + i^D)} \left( R - \frac{(b + c)}{\Delta p} \right) \end{aligned}$$

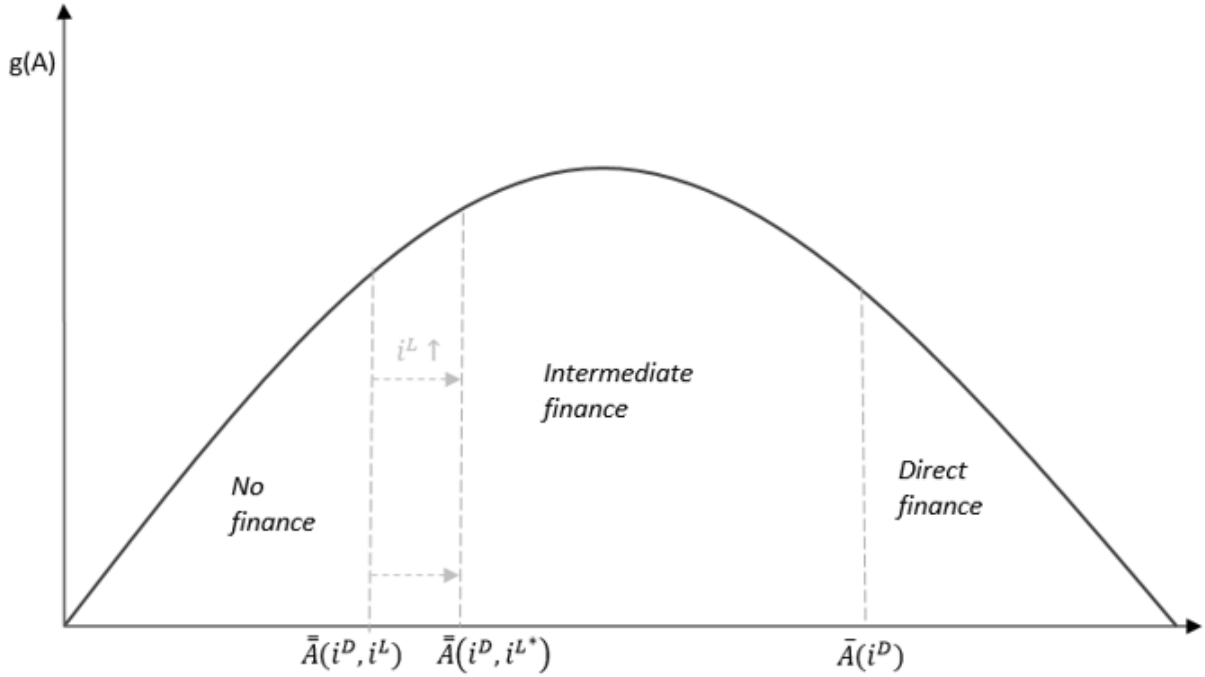
The first thing to notice is that under the assumption that monitoring is socially valuable<sup>8</sup>, i.e.  $c\Delta p < p_H(B - b)$ ,  $\bar{\bar{A}}(i^D, i^L) < \bar{A}(i^D)$ , The interpretation is that when funding is done through an intermediary, like a bank, the need for equity is reduced, making funding possible for capital poorer firms.

Figure 2 displays how projects are financed in this economy under the assumption that the distribution of capital between the firms,  $G(A)$  is approximately normal.

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<sup>8</sup> See page 674 in Holmström and Tirole (1997)

**Figure 2: The distribution of firms between no -, intermediate - and direct finance**



Furthermore, this theory gives us the opportunity to analyze the market for banking capital. Specifically, since

$$D_b = \left[ G(\bar{A}(i^D)) - D(\bar{A}(i^D, i^L)) \right] I_b(i^L),$$

is the demand for bank capital under the previous assumptions, it should equal the bank's lending capacity ( $C_b$ ) in equilibrium.

$$D_b = \left[ G(\bar{A}(i^D)) - D(\bar{A}(i^D, i^L)) \right] I_b(i^L) = C_b$$

This demand for informed bank capital is, for a given  $i^D$ , decreasing in the bank's lending rate since  $I_b(i^L)$  is decreasing in  $\bar{A}(i^D, i^L)$  is increasing in  $i^L$ . Let us for instance say that the banks' lending rate increases to  $i^{L*}$ , while the deposit rate  $i^D$  is kept constant. In Figure 2 this will reduce the gap between intermediate and direct financing and leave more poorly capitalized firms without financing. This mechanism is, in its simplicity, the basis for the financial accelerator effect and bears similarities to those presented in more full-fledged models, such as Bernanke and Gertler (1989) and Bernanke, Gilchrist and Gertler (1999).

To a glance at this as well, the following contains a short version of the agency costs that arise in Bernanke, Gilchrist and Gertler (1999). A complete account of the theoretical model can be found in Bernanke, Gilchrist and Gertler (1999), and I will only review the main results here.

In the paper, firms demand loans in order to satisfy a wanted capital-to-assets ratio, which is determined through a function of the discounted rate of return to capital or premium on external financing. This premium is a result of costly state verification, which arises from an idiosyncratic shock to technology between firms. The key relationship is:

$$k = \psi(s)$$

Where  $k$  is the capital-to-assets ratio (defined as the price of capital ( $Q$ ) times the amount of capital ( $K$ ) divided by net worth ( $N$ ) of firm  $j$ ;  $Q_t K_{t+1}^j / N_{t+1}^j$ ) and  $s$  the discounted expected rate of return to capital investments ( $s = E\{R_{t+1}^k\} / R_{t+1}$ ). Bernanke, Gilchrist and Gertler show that  $\psi'(s) > 0$  for all equilibrium supporting values of  $s$ <sup>9</sup>.

Alternatively, to get a clearer picture of what is meant by premium, the result above can be expressed as:

$$E\{R_{t+1}^k\} = s \left( \frac{N_{t+1}^j}{Q_t K_{t+1}^j} \right) R_{t+1}$$

Where  $s$  – the premium – is now inversely connected to the share of the investment covered by the firms net worth ( $s'(\cdot) < 0$ ). From this, we see that, in equilibrium, a decrease in borrower net worth, following an economic downturn, decrease the firm's stake in the project and thereby increase the external finance premium. Therefore, in connection with a reinforcing relationship between business cycle fluctuations and credit markets, this model implies, quite reasonably, that negative shocks to aggregate production result in, not only higher probabilities of default, but also an increase in the cost of external finance. This result is key in the model and makes the premium on external finance the force which drives the financial accelerator.

In connection to Kyotaki and Moore (1997), which I will return to shortly in my replication of H&J's 2008 paper, the demand for external capital is described without a premium on external finance, and so  $\psi(s) = 1$ . Borrowers are then credit constraint by the amount of collateral they can pledge, and cannot lend above their wealth level (value of their land) ( $Q_t K_{t+1}^j = N_{t+1}^j$ ).

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<sup>9</sup> In Bernanke, Gilchrist and Gertler (1999) it is shown that  $s$  must be less than some  $s^*$  in equilibrium.

### 3 A reconstruction of Hammersland and Jacobsen's (2008) financial accelerator estimation

In this sub-chapter, I present the result from my attempt at replicating H&J's "*The Financial Accelerator: Evidence using a procedure of Structural Model Design*" from 2008. In the replication, I have used the model design described in the original paper to the best of my ability. Also seeing, as this is not the main issue of the thesis, I will keep the discussion relatively short and refer readers to H&J for more detailed descriptions of the model design and the method used. The purpose of this replication is for one, just that; to replicate.

Replication, and thereby validation, is in my opinion a somewhat forgotten art in the field of economics, and should be given more focus. Secondly, this chapter should also serve to give the readers some detailed information about the financial accelerator mechanism in Norway.

Due to data revisions, and some ambiguities in the model specification, an exact replication cannot be expected. For example, I discover that some parts of the structure are refuted by t-tests. It does however not follow, because of the data revisions, that these statistics would have been problematic with H&J's original data, as can be seen in Appendix A.1 (containing H&J final structure).

The variable set used by H&J consists of credit to firms and real GDP for mainland Norway. Together with the Oslo Stock Exchange's main index, for the whole economy, these three variables make up the endogenous part of the model. In addition, an oil price variable is added as an exogenous variable as it, due to the structure of the Norwegian economy, is thought of as having a great deal of impact on the stock exchange index.

To first reveal any large discrepancies between the datasets, I have constructed some graphs similar to Figure 2 (a and b) and Figure 4a in H&J, which can be seen in Appendix A.2. The graphs, though somewhat different due to inequalities in scale, do not reveal any large discrepancies compared to those in the original paper. However, if the original model has been very finely adapted to the data, it is of course a possibility that even small changes (hardly visible to the eye) will imply differences in covariates that may affect (some of) the estimated parameters results.

In connection with possible differences in modelling specification, it should be mentioned that the modelling approach used in H&J stand out from today's mainstream approaches. The reasons are, in the authors' own words, that:

*“The inherent problem of structural model design is that there is no way to test for the exact identifying restrictions of a structural or simultaneous equation model. As long as the exact identifying restrictions reflect subjective a priori information of substantial interest and consequence for the properties of the model, this introduces necessarily a significant trace of arbitrariness in model design and specification. In fact, in some cases one might even speak of design where the outcome is more or less fully driven by the researcher's a priori subjective belief or wishful thinking!”*

H&J instead propose an original data-based structural model design, where no a priori restrictions are made on the model, and identification is ensured through the use of “structural dummies”, i.e. dummies uniquely effecting only one of the structural equations at a time. This inherently puts a lot of responsibility on the dummies used, and the behavior properties they contain. From what is extractable from the analysis of H&J the dummies used there, and therefore also in my replication study, are: A dummy for the second quarter in 1986, representing the devaluation of the Norwegian Krone and one for the second quarter in 1997 when the emerging market crisis resulted in an appreciation of the krone. Both of these are potential structural dummies for the GDP equation. In the behavioral equation for the asset prices (stock market), the stock market crash in the fourth quarter of 1987 is a natural choice. In addition D1992Q3 - a dummy representing the ERM exchange rate systems collapse – is also included in the asset price equation. The last structural dummy, which affects the credit equation uniquely, is one representing an extraordinary credit expansion by the two Norwegian firms Hydro and Norske Skog, in the third quarter of 2000. To account for other irregularities in the data additional dummies are also included for the fourth quarter of 1991 and one for the fourth quarter in 1992, the latter accounting for lagged effects of the ERM exchange rate system collapse.

The starting point of H&J's analysis is the standard VECM:

$$\Delta X_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \phi D_t + \epsilon_t \quad (1)$$



where  $X_t$  represents a  $p \times 1$  vector of endogenous variables,  $Y_t = (X_t'; Z_t')$  a  $(p + q) \times 1$ , vector where  $Z_t$  is a  $q \times 1$  vector of exogenous variables and  $k$  the order of the VAR.  $D_t$  is a vector composed of contemporaneous and lagged differences of the model exogenous variables,  $Z_t$ , deterministic variables like dummies, a trend and a constant.  $\epsilon_t$  is a Gaussian white noise term with covariance matrix  $\Sigma$ . The rank of the  $\Pi$  matrix gives us information about the cointegration properties of the model. In the case the rank,  $r$ , is less than full, i.e., less than  $p$ , the  $\Pi$  matrix may be written as the product of a  $p \times r$  matrix,  $\alpha$ , and a  $(p + q) \times r$  matrix,  $\beta$ , with full column rank equal to  $r < p$ . The level term in equation (1) can then be written as  $\Pi Y_{t-1} = \alpha \beta' Y_{t-1}$  where  $\beta' Y_{t-1}$  represents the  $r$  co-integrating linear combinations of the variables while the  $\alpha$  matrix has the interpretation of a coefficient matrix with error correction coefficients or loadings.

A cointegration analysis, including an estimation of the long-term relationships between the cointegrated variables, was then performed on the second level vector autoregressive version of the model<sup>10</sup>. The results of this step in my analysis, and the corresponding results presented by H&J, are shown in Table 1.

**Table 1: Johansen's test for the number of cointegrated vectors**

*VAR 2. Order, restricted trend, unrestricted constant and unrestricted centered seasonal dummies. Sample period: 1986Q2-2006Q3.*

<b>Results from reconstruction:</b>			<b>Results from Hammersland and Jacobsen (2008)</b>		
<i>Trace Eigenvalue Test:</i>			<i>Trace Eigenvalue Test:</i>		
$H_0$	$H_1$	Values of test statistics	$H_0$	$H_1$	Values of test statistics
$r = 1$	$r \leq 3$	69.338 [0.000] **	$r = 1$	$r \leq 3$	84.200 [0.000] **
$r \leq 1$	$r \leq 3$	32.936 [0.004] **	$r \leq 1$	$r \leq 3$	35.400 [0.002] **
$r \leq 2$	$r \leq 3$	11.874 [0.063]	$r \leq 2$	$r \leq 3$	14.089 [0.025]*

1)The value in parentheses are the respective tests' significance probabilities (p-values)

2) \* and/or \*\* signify that the test is significant at a level of 5 and 1 % respectively

<sup>10</sup> The use of a second order VAR is due to the fact that this is a valid reduction of the 6 order VAR. This is also the case in my analysis and is supported by the F statistic for the elimination of all lags greater than 2:

In addition, the normality heteroscedasticity and autoregression tests for the VAR(2) doesn't detect any problems:

Vector AR 1-5 test:  $F(45,131) = 0.91009 [0.6336]$

Vector Normality test:  $\chi^2(6) = 9.0160 [0.1727]$

Vector Hetero test:  $F(138,276) = 1.2077 [0.0956]$

In all cases, the figure in the parenthesis is the test significance probability. As a remark, I should mention that the significance level of normality and heteroscedasticity is low and far less than their respective levels from Hammersland and Jacobsen original results.

The trace tests in Table 1 show that the results of this analysis differ slightly from those of H&J. Most interestingly, the third cointegrated relationship, significant at a 5% level in the original paper, is now insignificant at the same level. It should however be noted that the original paper is somewhat unclear on whether the constant is restricted to lie in the loading matrix space ( $\alpha$ ) or not. Restricting the constant give results even more support in favor of three cointegrated relationships<sup>11</sup>. The trace test based on the model with an unrestricted constant does however seem more reasonable in this context, since an unrestricted constant will be imposed moving forward. It is therefore the one presented (in the main text). To maintain comparable results, and because of the marginality the insignificance of the third relationship, I will continue with the third cointegrated relationship imposed, as in the original paper.

Continuing with  $r=3$  allows me to formulate the restrictions on  $\beta$  matrix as in the 2008 paper. The results and the way they differ from the original, are shown in Table 2.

However, before I discuss the results, it is important to understand the underlying restrictions and why they are made. In H&J, the restrictions are made to satisfy an over-identified restrictions test, while still constituting interpretable relationships and give an identified beta matrix. The result is therefore that they do not find any long-run link between the real side of the economy and the financial side. The restrictions imposed seem to be the well chosen as it is hard to find other restrictions that are both interpretable and valid, while still ensuring identification. This is an interesting result and one that brings the empirical relevance of the Modigliani-Miller theorem back into play.

Taking a closer look at the results, the first restriction, made as a long run GDP relationship, imply that GDP is a trend stationary variable with a yearly growth rate of approximately 2.9%

<sup>11</sup> Restricting the constant, as well as the trend, give results strongly supporting three cointegrated relationships:

**Table 1-B: Johansen's test for the number cointegrated vectors**

VAR 2. Order, Restricted trend and constant, unrestricted centered seasonal dummies. Sample period: 1986Q2-2006Q3.

<i>Results from reconstruction:</i>			<i>Results from Hammersland and Jacobsen (2008)</i>		
<i>Trace Eigenvalue Test:</i>			<i>Trace Eigenvalue Test:</i>		
$H_0$	$H_1$	<i>Values of test statistics</i>	$H_0$	$H_1$	<i>Values of test statistics</i>
$r = 1$	$r \leq 3$	92.602 [0.000] **	$r = 1$	$r \leq 3$	84.200 [0.000] **
$r \leq 1$	$r \leq 3$	43.545 [0.000] **	$r \leq 1$	$r \leq 3$	35.400 [0.002] **
$r \leq 2$	$r \leq 3$	20.838 [0.001]**	$r \leq 2$	$r \leq 3$	14.089 [0.025]*

1)The value in parentheses are the respective tests' significance probabilities (p-values)

2) \* and/or \*\* signify that the test is significant at a level of 5 and 1 % respectively

(the same as in H&J). The next cointegrated relationship maps the long-term connection between credit to firms and stock price fluctuations as one to one.

---

**Table 2: The identified system of cointegrated linear combinations given  $r=3$ , the loading matrix and test for overidentifying restrictions.**

**Result from reconstruction:**

*The identified system of cointegrated linear combinations given three cointegrated relations:*

$$\begin{pmatrix} \hat{\beta}_{11} & \hat{\beta}_{21} & \hat{\beta}_{31} & \hat{\beta}_{41} & \hat{\beta}_{51} \\ \hat{\beta}_{12} & \hat{\beta}_{22} & \hat{\beta}_{32} & \hat{\beta}_{42} & \hat{\beta}_{52} \\ \hat{\beta}_{13} & \hat{\beta}_{23} & \hat{\beta}_{33} & \hat{\beta}_{43} & \hat{\beta}_{53} \end{pmatrix} \begin{pmatrix} gdp_t \\ c_t \\ s_t \\ poil_t \\ TREND_t \end{pmatrix} = \begin{pmatrix} gdp_t - 0.00724 TREND_t \\ (0.0004) \\ c_t - s_t \\ s_t - 0.1547 poil_t - 0.0127 TREND_t \\ (0.08) \quad (0.002) \end{pmatrix}$$

*Error correction coefficient matrix:*

$$\begin{matrix} \Delta gdp \\ \Delta c \\ \Delta s \end{matrix} : \begin{pmatrix} \hat{\alpha}_{11} & \hat{\alpha}_{12} & \hat{\alpha}_{13} \\ \hat{\alpha}_{21} & \hat{\alpha}_{22} & \hat{\alpha}_{23} \\ \hat{\alpha}_{31} & \hat{\alpha}_{32} & \hat{\alpha}_{33} \end{pmatrix} = \begin{pmatrix} -0.1475 & -0.007 & +0.005 \\ (0.0805) & (0.0158) & (0.0217) \\ 0.567 & -0.118 & -0.114 \\ (0.134) & (0.026) & (0.036) \\ 0.622 & -0.158 & -0.338 \\ (0.401) & (0.079) & (0.108) \end{pmatrix}$$

*LR-test of overidentifying restrictions:  $\chi^2(3) = 3.0817 [0.3792]$*

**Results from Hammersland and Jacobsen (2008):**

*The identified system of cointegrated linear combinations given three cointegrated relations:*

$$\begin{pmatrix} \hat{\beta}_{11} & \hat{\beta}_{21} & \hat{\beta}_{31} & \hat{\beta}_{41} & \hat{\beta}_{51} \\ \hat{\beta}_{12} & \hat{\beta}_{22} & \hat{\beta}_{32} & \hat{\beta}_{42} & \hat{\beta}_{52} \\ \hat{\beta}_{13} & \hat{\beta}_{23} & \hat{\beta}_{33} & \hat{\beta}_{43} & \hat{\beta}_{53} \end{pmatrix} \begin{pmatrix} gdp_t \\ c_t \\ s_t \\ poil_t \\ TREND_t \end{pmatrix} = \begin{pmatrix} gdp_t - 0.0073 TREND_t \\ (0.00016) \\ c_t - s_t \\ s_t - 0.26 poil_t - 0.01 TREND_t \\ (0.09) \quad (0.002) \end{pmatrix}$$

*Error correction coefficient matrix:*

$$\begin{matrix} \Delta gdp \\ \Delta c \\ \Delta s \end{matrix} : \begin{pmatrix} \hat{\alpha}_{11} & \hat{\alpha}_{12} & \hat{\alpha}_{13} \\ \hat{\alpha}_{21} & \hat{\alpha}_{22} & \hat{\alpha}_{23} \\ \hat{\alpha}_{31} & \hat{\alpha}_{32} & \hat{\alpha}_{33} \end{pmatrix} = \begin{pmatrix} -0.13 & -0.0163 & -0.003 \\ (0.064) & (0.0134) & (0.0187) \\ 0.434 & -0.077 & -0.061 \\ (0.104) & (0.022) & (0.03) \\ 0.532 & -0.176 & -0.357 \\ (0.34) & (0.071) & (0.099) \end{pmatrix}$$

*LR-test of overidentifying restrictions:  $\chi^2(3) = 0.8386 [0.8402]$*

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The first two cointegrated relationships (the second one by definition) are almost identical to the ones found in H&J. The third one, the relationship between Norwegian stock -and oil prices and a trend, does contain a small discrepancy. The stronger long run relationship between asset price growth for a given oil price, being approximately 5% here, while 4% in H&J is only natural seeing as the relationship between the stock and oil prices is much weaker in this reproduction. As opposed to H&J, where a one percent increase in oil prices gave a quarter of a percent increase in the stock market, I only find this mapping to be one to 0,155%. The reason for this difference is somewhat unclear and it is hard to justify this discrepancy as being a result from revisions and/or differences in data alone. It might however be connected to small differences in model specifications and/or “overfitting” of the data.

Since some differences are to be expected and in order to use cointegrated relationships better describing the long run structure of my datasets, I will continue with the long-run structure defined by this reconstruction.

The next step of the analysis is to identify and estimate the simultaneous equation model. By multiplying (1) with a contemporaneous feedback matrix  $B$ , we obtain the following structure:

$$B\Delta X_t = B\Pi Y_{t-1} + \sum_{i=1}^{k-1} B\Gamma_i \Delta X_{t-i} + B\phi D_t + B\epsilon_t$$

Or, after defining  $B\Pi = B\alpha\beta' = \alpha^*\beta'$ ,  $B\Gamma_i = \Gamma_i^*$ ,  $B\phi = \phi^*$  and  $B\epsilon_t = u_t$  :

$$B\Delta X_t = \alpha^*\beta' Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i^* \Delta X_{t-i} + \phi^* D_t + u_t \quad (2)$$

Inserting for the already defined long run relationships, that is the  $\beta'$  matrix, we get the following matrix form:

$$\begin{aligned}
& \begin{pmatrix} 1 & \tilde{b}_{12} & \tilde{b}_{13} \\ \tilde{b}_{21} & 1 & \tilde{b}_{23} \\ \tilde{b}_{31} & \tilde{b}_{32} & 1 \end{pmatrix} \begin{pmatrix} \Delta gdp_t \\ \Delta c_t \\ \Delta s_t \end{pmatrix} = \begin{pmatrix} \tilde{\alpha}_{11}^* & \tilde{\alpha}_{12}^* & \tilde{\alpha}_{13}^* \\ \tilde{\alpha}_{21}^* & \tilde{\alpha}_{22}^* & \tilde{\alpha}_{23}^* \\ \tilde{\alpha}_{31}^* & \tilde{\alpha}_{32}^* & \tilde{\alpha}_{33}^* \end{pmatrix} \begin{pmatrix} gdp - 0.00724 TREND \\ c - s \\ s - 0.1547 poil - 0.0127 TREND \end{pmatrix}_{t-1} \\
& + \begin{pmatrix} \tilde{\gamma}_{11}^* & \tilde{\gamma}_{12}^* & \tilde{\gamma}_{13}^* \\ \tilde{\gamma}_{21}^* & \tilde{\gamma}_{22}^* & \tilde{\gamma}_{23}^* \\ \tilde{\gamma}_{31}^* & \tilde{\gamma}_{32}^* & \tilde{\gamma}_{33}^* \end{pmatrix} \begin{pmatrix} \Delta gdp_{t-1} \\ \Delta c_{t-1} \\ \Delta s_{t-1} \end{pmatrix} + \begin{pmatrix} \tilde{\lambda}_{11}^* & \tilde{\lambda}_{12}^* & \tilde{\lambda}_{13}^* & \tilde{\lambda}_{14}^* & \tilde{\lambda}_{15}^* \\ \tilde{\lambda}_{21}^* & \tilde{\lambda}_{22}^* & \tilde{\lambda}_{23}^* & \tilde{\lambda}_{24}^* & \tilde{\lambda}_{25}^* \\ \tilde{\lambda}_{31}^* & \tilde{\lambda}_{32}^* & \tilde{\lambda}_{33}^* & \tilde{\lambda}_{34}^* & \tilde{\lambda}_{35}^* \end{pmatrix} \begin{pmatrix} D1986Q2_t \\ D2000Q3_t \\ D1987Q4_t \\ D1992Q3_t \\ D1997Q2_t \end{pmatrix} \\
& + \begin{pmatrix} \tilde{\phi}_{11}^* & \tilde{\phi}_{12}^* & \tilde{\phi}_{13}^* & \tilde{\phi}_{14}^* & \tilde{\phi}_{15}^* & \tilde{\phi}_{16}^* & \tilde{\phi}_{17}^* & \tilde{\phi}_{18}^* \\ \tilde{\phi}_{21}^* & \tilde{\phi}_{22}^* & \tilde{\phi}_{23}^* & \tilde{\phi}_{24}^* & \tilde{\phi}_{25}^* & \tilde{\phi}_{26}^* & \tilde{\phi}_{27}^* & \tilde{\phi}_{28}^* \\ \tilde{\phi}_{31}^* & \tilde{\phi}_{32}^* & \tilde{\phi}_{33}^* & \tilde{\phi}_{34}^* & \tilde{\phi}_{35}^* & \tilde{\phi}_{36}^* & \tilde{\phi}_{37}^* & \tilde{\phi}_{38}^* \end{pmatrix} \begin{pmatrix} \Delta poil_t \\ \Delta poil_{t-1} \\ Constant \\ S1_t \\ S2_t \\ S3_t \\ D1991Q4_t \\ D1992Q4_t \end{pmatrix} + \begin{pmatrix} \tilde{u}_{1t} \\ \tilde{u}_{2t} \\ \tilde{u}_{3t} \end{pmatrix} \tag{3}
\end{aligned}$$

It should be plain to see that (3), as it stands above, is not identified. This is however where the structural dummies, defined above, come in to play their role. In line with H&J, the identification problem is solved, not by making the more traditional assumptions (of a lower or upper triangular response matrix and a diagonal covariance matrix (SVAR) or other a priori restrictions on the variables), but instead by using the dummies as auxiliary tools by restricting them to uniquely affect only one of the equations. That is, restrictions are only made on the  $\Lambda$  matrix. There are however many ways in which the  $\Lambda$  matrix could be restricted, but it is important to recognize that the restrictions should be made so that the dummies only affect the equation that they are intended to inform structurally. As explained in more detail by H&J there are four different ways to restrict the  $\Lambda$  matrix in order to ensure this<sup>12</sup>. Here, I will use the one referred to as *default*, restricting D1986Q2, D2000Q3 and D1987Q4 to appear in only one of the equations each, that equation corresponding to how the structural dummies were defined a few pages back. This gives us the restricted  $\Lambda$  matrix as:

$$\begin{pmatrix} \tilde{\lambda}_{11}^* & 0 & 0 & \tilde{\lambda}_{14}^* & \tilde{\lambda}_{15}^* \\ 0 & \tilde{\lambda}_{22}^* & 0 & \tilde{\lambda}_{24}^* & \tilde{\lambda}_{25}^* \\ 0 & 0 & \tilde{\lambda}_{33}^* & \tilde{\lambda}_{34}^* & \tilde{\lambda}_{35}^* \end{pmatrix}$$

<sup>12</sup> H&J also show that it is indifferent which method you use in the end.

The final, but far from straightforward, step is the reduction of this identified SVECM to a parsimonious over-identified system. What inherently makes this step especially hard to reproduce is, according to H&J:

*“This final process of reduction takes on a fully simultaneous perspective where all equations are reduced and designed jointly...*

*...The fact that this procedure of reduction is highly informed by theory and a desire of ending up with a model with good interpretable properties is what makes it difficult to automatize. As one reduction imposed early in the process might turn out to have dire consequences for the possibility of ending up with a model with the desired properties, the process of design will necessarily imply a lot of back and forth searching with theory and interpretation as the rule of conduct. Also as we in the process of reduction have given priority to theory and interpretation, we have occasionally had to resort to brute force, in the sense of accepting partial reductions that would otherwise have been marginally rejected if one exclusively gave priority to the outcome of tests or information criteria. This further complicates the use of automatic reduction procedures as it involves a great deal of ad hoc judgment as to whether the end justifies the means in the individual cases considered”.*

It is therefore impossible, seeing as the former results are not completely in line with the original paper's, to track how the final model of H&J (Appendix A.1) came to be. Therefore, in order not to take anything away from the expert knowledge of the authors of the original paper, I will here present two different final structures. One where the final equations are specified exactly as in H&J and another where I have used a stricter, and perhaps somewhat naïve, approach to model reduction. In the later, reduction of the identified SVECM in (3) is undertaken manually by a general-to-specific (GETS) method where, looking at the entire system, the most insignificant regressor is removed from each estimation until all remaining regressors are significant at the 5% level. The difference between the two structures, which are presented as models (4) and (5), in Tables 3 and 4, respectively, is substantial. Both do however display themselves as valid reductions of the exactly identified model. This also emerges in the forecast graphs in Appendix A.3, where the similarities hint at similar restricted reduced forms as well. Thorough readers might also notice that these forecasts are quite alike to the ones made by H&J in the period ahead of my forecasts (not presented here).

H&J's final structure is used, not only are insignificant regressors added, but significant ones are also removed. This is however understandable, and again quoting the authors of the original paper, the reason is "*a desire of ending up with a model with good interpretable properties*".

Looking more closely on the differences, the model designed by the stricter GETS approach is notably different from the one using H&J's final structure. One interesting aspect of (5) in particular, is the parameter of real GDP's contemporaneous effect in the asset price equation, indicating that when production increases, the stock market declines. It seems unlikely to me that the main part of the Oslo stock exchange exist of countercyclical stocks. The most interesting one, in relation to the topic of this thesis, is however the missing contemporaneous two-directional link between credit and real activity – one of the main results in H&J. In fact, in the final specification of the equation for GDP in (5), there are no causal relationship that includes either credit or asset prices at all – a result that, if one take the model at face value, actually refutes the existence of a financial accelerator.

This relationship, while not significant, is however present in (4), which utilizes the final structure of H&J. Here, one should also notice the presence of other insignificant regressors, and the omission of significant ones. This is however understandable and again quoting the authors of the original paper, the reason is "*a desire of ending up with a model with good interpretable properties*".

**Table 3: The estimated system using H&J's final model specification.**

$$\begin{aligned}
 & \begin{pmatrix} 1 & -0.097 & 0 \\ & (0.077) & \\ -0.67 & 1 & -0.081 \\ (0.197) & & (0.45) \\ 0 & -1.14 & 1 \\ & (0.32) & \end{pmatrix} \begin{pmatrix} \Delta gdp_t \\ \Delta c_t \\ \Delta s_t \end{pmatrix} \\
 &= \begin{pmatrix} -0.148 & 0 & 0 \\ (0.0487) & & \\ 0.37 & -0.045 & 0 \\ (0.09) & (0.009) & \\ 0 & 0 & -0.208 \\ & & (0.04) \end{pmatrix} \begin{pmatrix} gdp - 0.00724 TREND \\ c - s \\ s - 0.1547 poil - 0.0127 TREND \end{pmatrix}_{t-1} \\
 &+ \begin{pmatrix} -0.487 & 0 & 0 \\ (0.077) & & \\ 0 & -0.137 & 0 \\ & (0.082) & \\ 0.667 & 0.26 & 0.446 \\ (0.213) & (0.236) & (0.09) \end{pmatrix} \begin{pmatrix} \Delta gdp_{t-1} \\ \Delta c_{t-1} \\ \Delta s_{t-1} \end{pmatrix} \\
 &+ \begin{pmatrix} 0 & 0 & 1.781 & -0.525 & -0.092 & -0.0695 & 0 & 0 \\ & & (0.575) & (0.008) & (0.006) & (0.005) & & \\ -0.043 & 0 & -4.04 & 0.062 & 0.066 & 0.0335 & -0.085 & 0.066 \\ (0.023) & & (1.069) & (0.019) & (0.017) & (0.015) & (0.025) & (0.024) \\ 0.171 & 0 & 0.68 & 0 & 0 & 0 & 0 & 0 \\ (0.068) & & (0.134) & & & & & \end{pmatrix} \begin{pmatrix} \Delta poil_t \\ \Delta poil_{t-1} \\ Constant \\ S1_t \\ S2_t \\ S3_t \\ D1991Q4_t \\ D1992Q4_t \end{pmatrix} \\
 &+ \begin{pmatrix} 0.0594 & 0 & 0 & 0 & 0.054 \\ (0.015) & & & & (0.015) \\ 0 & 0.094 & 0 & 0 & 0 \\ & (0.025) & & & \\ 0 & 0 & -0.233 & -0.211 & 0 \\ & & (0.074) & (0.075) & \end{pmatrix} \begin{pmatrix} D1986Q2_t \\ D2000Q3_t \\ D1987Q4_t \\ D1992Q3_t \\ D1997Q2_t \end{pmatrix} + \begin{pmatrix} \bar{\epsilon}_{1t} \\ \bar{\epsilon}_{2t} \\ \bar{\epsilon}_{3t} \end{pmatrix}
 \end{aligned} \tag{4}$$

**System diagnostics and test of restrictions:**

LR test of over-identifying restrictions:  $\chi^2(26) = 30.020$  [0.2668]

Vector SEM-AR 1-5 test:  $F(45,164) = 0.88940$  [0.6701]

Vector Normality test:  $\chi^2(6) = 14.776$  [0.0221]\*

Vector Hetero test:  $F(114,335) = 1.1329$  [0.1988]



**Table 4: The estimated system using the strict structural GETS method.**

$$\begin{aligned}
 & \begin{pmatrix} 1 & 0 & 0 \\ -0.39 & 1 & 0 \\ (0.115) & & \\ 0.675 & -1.27 & 1 \\ (0.236) & (0.307) & \end{pmatrix} \begin{pmatrix} \Delta gdp_t \\ \Delta c_t \\ \Delta s_t \end{pmatrix} \\
 &= \begin{pmatrix} -0.136 & 0 & 0 \\ (0.046) & & \\ 0.574 & -0.113 & -0.107 \\ (0.123) & (0.024) & (0.034) \\ 0 & 0 & -0.195 \\ & & (0.039) \end{pmatrix} \begin{pmatrix} gdp - 0.00724 TREND \\ c - s \\ s - 0.1547 poil - 0.0127 TREND \end{pmatrix}_{t-1} \\
 &+ \begin{pmatrix} -0.497 & 0 & 0 \\ (0.077) & & \\ -0.318 & 0 & 0 \\ (0.148) & & \\ 0 & 0 & 0.541 \\ & & (0.09) \end{pmatrix} \begin{pmatrix} \Delta gdp_{t-1} \\ \Delta c_{t-1} \\ \Delta s_{t-1} \end{pmatrix} \\
 &+ \begin{pmatrix} 0 & 0 & 1.639 & -0.049 & -0.091 & 0.069 & 0 & 0 \\ & & (0.554) & (0.007) & (0.006) & (0.005) & & \\ 0 & 0 & -5.56 & 0.047 & 0.029 & 0 & -0.087 & 0.065 \\ & & (1.252) & (0.012) & (0.01) & & (0.026) & (0.027) \\ 0.139 & -0.128 & 0.647 & 0 & -0.062 & 0 & 0 & 0 \\ (0.064) & (0.061) & (0.128) & & (0.023) & & & \end{pmatrix} \begin{pmatrix} \Delta poil_t \\ \Delta poil_{t-1} \\ Constant \\ S1_t \\ S2_t \\ S3_t \\ D1991Q4_t \\ D1992Q4_t \end{pmatrix} \\
 &+ \begin{pmatrix} 0.074 & 0 & 0 & 0 & 0.066 \\ (0.016) & & & & (0.016) \\ 0 & 0.105 & 0 & 0 & 0 \\ & (0.026) & & & \\ 0 & 0 & -0.259 & -0.234 & 0 \\ & & (0.076) & (0.075) & \end{pmatrix} \begin{pmatrix} D1986Q2_t \\ D2000Q3_t \\ D1987Q4_t \\ D1992Q3_t \\ D1997Q2_t \end{pmatrix} + \begin{pmatrix} \bar{\epsilon}_{1t} \\ \bar{\epsilon}_{2t} \\ \bar{\epsilon}_{3t} \end{pmatrix}
 \end{aligned} \tag{5}$$

**System diagnostics and test of restrictions:**

LR test of over-identifying restrictions:  $\chi^2(28) = 24.710$  [0.6435]

Vector SEM-AR 1-5 test:  $F(45,167) = 0.85931$  [0.7196]

Vector Normality test:  $\chi^2(6) = 6.4676$  [0.3729]

Vector Hetero test:  $F(114,335) = 1.1823$  [0.1291]

With this in mind, and though there might be some instability in the model design of H&J, the bottom line is that they end up with a model with far more realistic and interpretable content than the one designed through a stricter approach. In connection to the theory, the story told by the evidence in H&J also mimic that of the theoretical Kyotaki-Moore model (1997). I would therefor, to some degree, support the original papers results, pointing in the direction of

a short-term financial accelerator effect working in the Norwegian economy and a long-term view, more in line with the Modigliani-Miller theorem, indicating no connection between the real and financial side. That said, the refusal of a financial accelerator mechanism in the stricter model and the other general discrepancies between the two designs' coefficients does dampen my overall belief in the results<sup>13</sup>.

As a remark to the methodology, I have sympathy with authors' approach and attempt to let the data "talk" as freely as possible. It will be exciting to see if the method can be developed further and become even more stable and easy-to-follow.

As a final note, I find it interesting that the authors of the original paper comment on the lack of an interest rate mechanism in a footnote on page 10 (in H&J). Moreover, while H&J did not succeed in designing a well-specified and interpretable simultaneous model with interest rates, interest rates, as a price mechanism, might still have a role in linking the financial and real side of the economy. In light of the short-term financial accelerator mechanism evidence, countercyclical interest margins actually seem even more realistic.

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<sup>13</sup> As a way forward, future research should attempt to expand the timeframe of the model to see how that influences the results. This however, goes beyond the scope of this thesis.

## **4 The development in the banks' interest margins**

I now turn to the key mechanism the financial accelerator theory of Bernanke, Gilchrist and Gertler (1999), namely the interest premium (or nominal interest margin). In their model, the interest rate on loans rise in response to higher risk in the market, brought on by, a negative shock to technology for instance. Empirically however, cyclicalities of nominal interest margin alone cannot to prove the existence of a financial accelerator. Together with the results from H&J however, the presence of countercyclical movements in the interest margin will go a long way in providing evidence that interest rates should have a place in empirical representation of the financial accelerators on Norwegian data.

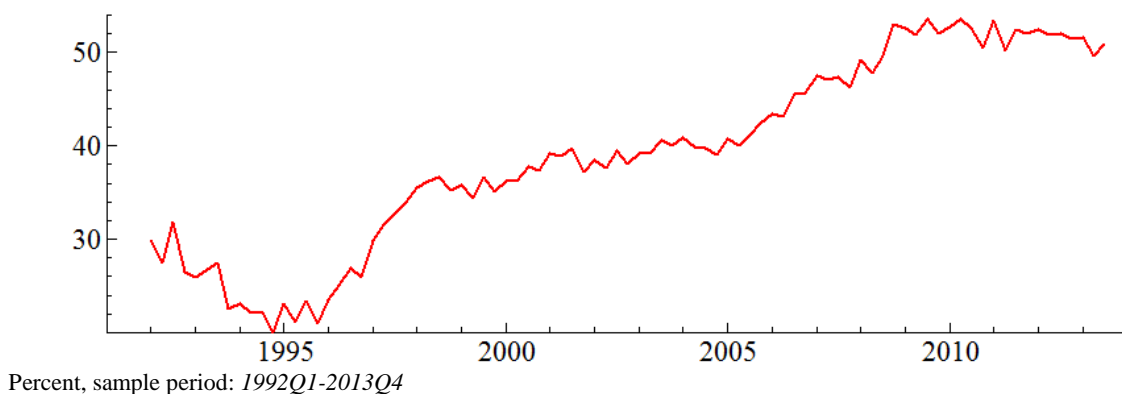
### **4.1 A definition of the Interest margin and some stylized facts**

#### **4.1.1 Defining a Weighted average cost of capital funding cost and an interest margin**

A documentation of the cyclicalities of interest margins must start by defining how you measure the margins. Ideally, we want a measure of the difference between the banks interest earnings from a loan (that is, the lending rate) and the corresponding funding cost of that loan. Historically, deposits have been the main source of bank funding, and a widely used measure of the interest margin, or interest spread, is therefore the difference between the lending and deposit rate of banks. However, the real costs of banks' loan funding is trifold and should more precisely be separated into; equity funding, deposits and wholesale funding. Starting with the latter, the banks' share of marked/wholesale finance, this ratio tends to fluctuate over time, as can be seen in Figure 3. The graph shows that after the banking crisis of the early 1990's, the market's share has again started to rise and now constitutes about 50% of banks' funding in Norway (Norges Bank, 2013 (1)). Moreover, banks typically set aside some of its capital to back the loans it grants, and since the introduction of Basel 1 in 1991, this has even become an unambiguous requirement. The required return on this capital should therefore also be taken into account when defining banks' funding costs. The spread between the

average lending rate and average deposit rate therefore seem to have too little nuance in accounting for all the different cost of loanable funds.

**Figure 3: Wholesale funding share of banks**



A measure that includes all these sources of funding is the net interest margin. The net interest margin, or NIM for short, measures the spread between the banks' interest earnings and expenses, also including the cost of equity, over their total (interest-earning) assets. As this measure accounts for the size of the banks' balance sheets and does not including any actual interest rates, it is effectively a measure of the banks' return on available assets. However, since the NIM, as oppose to the interest spread between the lending- and deposit rate, does accounts for rises and falls in credit, non-performing assets and losses, the NIM might not be as suitable for analyzing cyclical<sup>14</sup>. The developments in the NIM might nonetheless be relevant, as it, under the countercyclical nominal interest margin hypothesis, can indicate the smoothening effects, the proposed cyclical<sup>14</sup>, has on the NIM over time. In this interpretation, countercyclically of interest margin is merely a mechanism dampening the volatility in the banks' rate of return on total assets over time. Since banks' lending follow the business cycle, a relatively smooth development in the NIM, might imply that the interest margin is countercyclical and provide additional reasoning for why that is.

Having discarded NIM as an appropriate measure, I will nonetheless not stick with the lending-deposit rate spread. I instead look at possible definitions of the nominal interest margin (henceforth, interest margin), that fits the funding costs of banks better. In this, I turn to a *Weighted Average Cost of Capital (WACC)* approach, where equity, deposits and wholesale funding are all incorporated. My defined funding cost build on the work of Vale (2011), who defined banks funding cost using the equity ratio and the deposit rate. Having

<sup>14</sup> As this might not be so intuitive, a stylized example is provided in Appendix B

eliminated other possibilities, I will now elaborate on the two WAAC based measures that I found to be most relevant and fitting. Intuitively, neither of the two definitions represent a perfect measure of banks' funding costs. However, both manage to incorporate and distinguish between the cost of equity, wholesale funding and deposits, which is what I aim at here.

The two following WACC definitions of bank funding cost are suggested:

#### **Alternative one:**

$$\text{Funding cost} = CAR * R_E + (1 - CAR)[\gamma NIBOR + (1 - \gamma)R_D]$$

In this expression,  $CAR$  is the banks' capital adequacy ratio,  $R_E$  is the return on bank equity,  $\gamma$  is the wholesale funding share of the banks,  $NIBOR$  is the Norwegian money market rate (Internal bank offered rate) and  $R_D$  is the average interest rate earned on deposits.  $CAR$  is used as a proxy for the equity to total asset ratio. The distinction between deposits and wholesale funding is made in order to account for a rise in banks' wholesale funding share over the last 20 years (see Figure 3). According to Statistics Norway (SSB), while 56% of banks' wholesale funding came from the internal markets in October 2012<sup>15</sup>, borrowing from Norwegian banks only made out approximately 4% of this (See Figure 4). In light of this, using NIBOR as the proxy for wholesale funding costs might seem like a strong assumption. The remaining wholesale funding costs, associated mainly with bonds and certificates, are also only assumed to follow the NIBOR rate<sup>16</sup>. With this in mind, the domestic- versus foreign market funding argument, led me to an alternative definition.

#### **Alternative two:**

$$\text{Funding cost} = CAR * R_E + (1 - CAR)[\gamma((0.5 * LIBOR) + (0.5 * NIBOR)) + (1 - \gamma)R_D]$$

In this second approach, LIBOR represents the 3 month USD LIBOR rate and, since banks mostly lend in dollars due to its favorable liquidity (NOU, 2001:1, pg. 91-92), it is used as a proxy for the cost of loans from foreign banks. The use of both the LIBOR and the NIBOR rate is supposed to account for the approximate distribution of wholesale funding between foreign and domestic markets. Here, the ratio 50/50 seems reasonable in the light of the current distribution of wholesale funding (again, see Figure 4), but there would be uncertainty

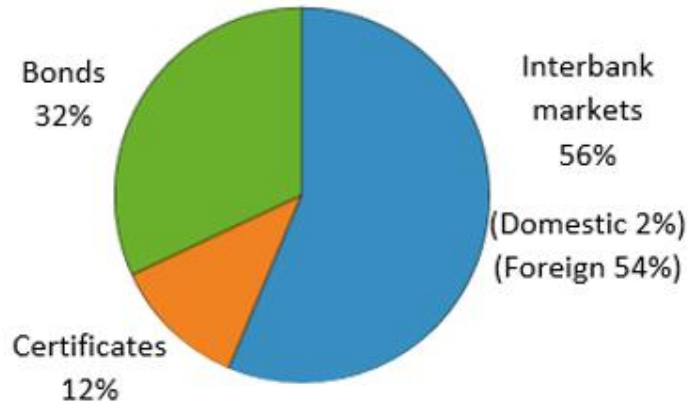
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<sup>15</sup> The rest stem from deposits at Norges Bank, brokered deposits, certificates, etc.

<sup>16</sup> They are typically priced at a small markup over the NIBOR rate

regarding the consistency of this ratio throughout the entire timeframe of this thesis. NIBOR is used under the same assumptions as in alternative one.

**Figure 4: The approximate distribution of wholesale funding in Norwegian banks as of October 2012**



Source: SSB

When choosing between the two measures, alternative one, despite its simplicity, actually seems the most realistic. While definition two might seem more precise in dividing the wholesale market in two, the LIBOR rate cannot be said to show the correct cost of lending in dollars. For one, NIBOR differentiates itself from other internal bank offered rates, as it is actually determined by the cost of borrowing in dollars, and not based on internal loans and placements in Norwegian Kroner (NOU, 2001:1, pg. 91-92). This is again a result of the fact that Norwegian banks, dealing in a small internal market, finance themselves mostly from foreign sources. In addition, using the LIBOR would in any case be somewhat naïve since the currency risk involved can be substantial and banks typically avoid this risk through hedging. It would therefore also seem correct to turn to the no-arbitrage based theory on interest rate parity<sup>17</sup>, and use the NIBOR rate as a cost proxy for all the wholesale funding, in any case. Also by not adopting the second option, I avoid the added inaccuracy of the approximate wholesale funding distribution. In conclusion, and in what follows, the funding cost measure, specified as alternative one, will be used.

That being said, I also mentioned that neither of the definition represent perfect measures of banks funding costs. As far as general weaknesses to the measures go, the banks' internal

<sup>17</sup> To avoid riskless arbitrage opportunities, the theory of interest rate parity states that the premium paid to hedge for currency risk equals the ratio of the two currencies interest rates (Madura and Fox, 2011, pg. 249-251). In this example:

$$\text{Cost of hedging} = \frac{1 + \text{NIBOR}}{1 + \text{LIBOR}} - 1 \rightarrow 1 + \text{NIBOR} = (1 + \text{Cost of hedging}) * (1 + \text{LIBOR})$$

offered rate does not capture the exact cost of inter-market loans, bonds and certificates, which are typically priced at a small mark-up over this rate. Moreover, in contrast to costs, banks will also generate revenue from the wholesale market. Firstly, banks will typically invest some of their funds in the wholesale market to control for short-term liability risk<sup>18</sup>. Secondly, as banks occasionally have excessive deposits (some banks more than others) they will invest this in the wholesale market to generate revenue over the cost of these funds. It is nonetheless assumed, that the funds invested in the marked, are funds which banks are not able to lend out and that the cost and revenue from these funds cancel out. Overall, a possible effect of this inaccuracy is that the funding cost I estimate might be a little bit lower than the actual funding cost experienced by the banks.

A second weakness is the use of the capital adequacy ratio (CAR) as a proxy, due to lack of data on the equity ratio<sup>19</sup>. In the CAR, “capital” refers to both Tier 1 (primarily equity capital) and Tier 2 (supplementary capital) type capital, and this is denominated by the banks’ risk weighted assets<sup>20</sup>, not its total assets. Therefore, when compared to the equity ratio, the nominator will be higher while the denominator will be lower, giving us a higher ratio. Moreover, there is also some added uncertainty due to possible differences in the risk weighted assets and equity ratio’s development. However, even with this higher ratio, and even though equity is typically more expensive than debt (due to risk), the cost of equity funding is small in contrast to the other funding options. In addition, since a lower equity ratio would also increase the share of debt, the total effect of this, while quite uncertain, is assumed small.

There is also one additional complication with the equity part of the funding cost definition, namely lack of data on Norwegian banks required return on equity. Because of this, I adopt the Capital Asset Pricing Model (CAPM) approach to find an appropriate required return on equity ( $R_E$ ). This however, further enhances the uncertainty of the funding cost measure,

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<sup>18</sup> After the full implementation of Basel III, banks will be required to hold a certain amount of liquid assets to cover their 30 days short-term liabilities.

<sup>19</sup> It might seem strange that data on the CAR is available while data on the banks’ equity ratio are not. However, the CAR dataset was forwarded to me and was originally retrieved from the ORBOF database, which do not have access to, by Akram (2012).

<sup>20</sup> It is more accurately measured as: 
$$CAR = \frac{\text{Tier 1 Capital} + \text{Tier 2 capital}}{\text{Risk weighted asset}}$$

seeing as the empirical relevance of the CAPM is questionable, see for example Fama and French (2004).

The CAPM states that the expected return on asset  $j$  can be found through the risk free rate of return and the expected rate of return on a market portfolio relative to asset  $j$ 's  $\beta$ , according to:

$$R_j = R_f + \beta(R_m - R_f).$$

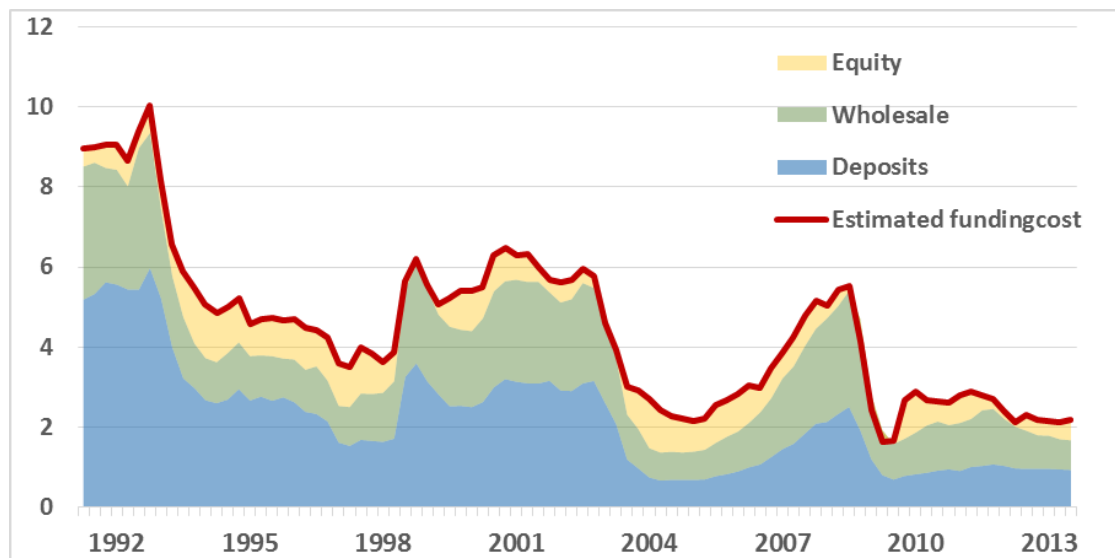
The  $\beta$  of asset  $j$  is measured as the covariance between the market portfolio and asset  $j$ , over the variance of the market portfolio. In my calculations, the return on the market portfolio is measured by the yearly growth in the Oslo stock exchange (OSEAX), while the 10-year government bond rate is used as the risk free rate. The  $\beta$  is calculated using the development of the DNB stock over the last 15 years (since 1998)<sup>21</sup> and is found to be 0.11.

Inserting the expression for the CAPM required rate of return in the funding cost equation yields:

$$FC = CAR(R_f + 0.11(R_m - R_f)) + (1 - CAR)[\gamma NIBOR + (1 - \gamma)R_D].$$

The estimated funding cost and the decomposed structure of it from 1992 -2013 can be seen in Figure 5.

**Figure 5: How the banks' funding cost is built up**



Percent. Sample period: 1991Q2-2013Q2.

<sup>21</sup> Another source of uncertainty. The correct  $\beta$  should be a combination of all banks  $\beta$ 's, but there are not that many banks on the Oslo stock exchange. The  $\beta$  I find is similar to the one used by Akram (2012).



Throughout the entire period, deposits have, not surprisingly, been the most significant funding cost for banks. This is despite the fact that deposits are typically a cheaper source of funding than wholesale or capital. Knowing that the share of wholesale finance increased over the last decade, it might be surprising to see that the wholesale cost share is not that much different from the deposit share at the end of the graph. This can however, be seen as a result of the beauty of self-regulation in the markets; As mentioned, over the last decade there has been an increasing demand for credit and to meet it, the banks have seemingly chosen to turn to the wholesale market in a much larger fashion, perhaps due to an increased supply here. I say choose, because banks are able, if they so wish, to create their own deposits by extending loans, and are therefore not reliant on their customers to make deposits first (McLeay, Radia and Thomas, 2014). However, as the fraction of deposit funding decreased this also increased the deposit rate, slowly lowering the gap to the wholesale interest rate (NIBOR) and equating the two sources of funding.

Finally, using the funding cost measure described above, I define the interest margin (IM) to be used for the remaining part of this thesis as:

$$IM = \text{Lending rate} - \text{Funding cost}.$$

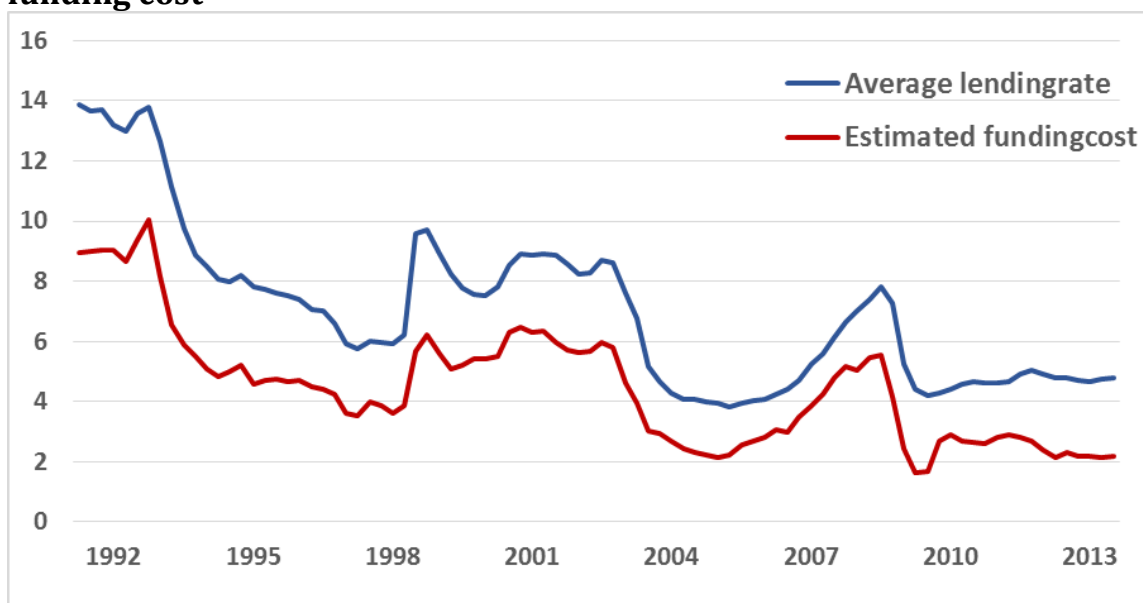
Here, the Lending rate refers to the banks' average lending rate.

#### **4.1.2 The stylized facts about the margin**

The development of the average lending rate and the calculated funding cost of Norwegian banks from 1992 to 2013 is plotted in Figure 6, while the interest margin's development can be seen in Figure 7.

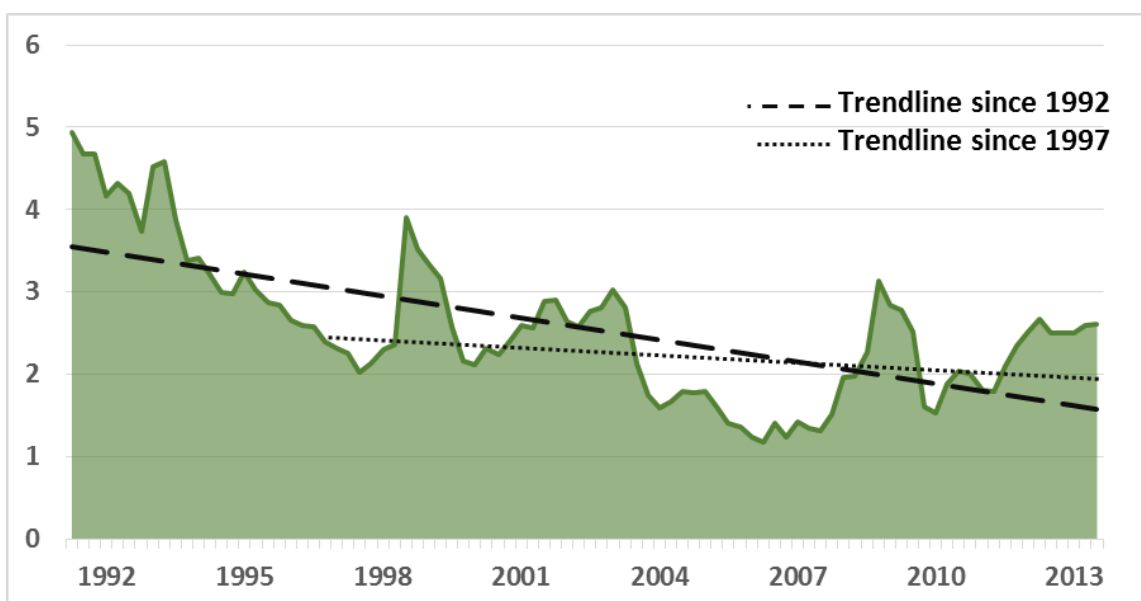
From the development of the interest rate margin from the end of the 1980-1990's banking crisis until today, we see that the margin is not necessarily a stationary processes, as one might expect. Specifically, from 1992 until today the IRM displays a decreasing trend and is today approximately 2 % lower than at the beginning of the 1990's. However, from around 1997 until today, the margins have shown a higher tendency towards being stationary, fluctuating around an almost horizontal trend. Looking at the history behind the margins and the theory presented in this thesis, the development in the early 90's is hardly surprising.

**Figure 6: Development of the average lending rate and the estimated funding cost**



Percent. Sample period: 1991Q2-2013Q2.

**Figure 7: Development of the estimated interest rate margin**

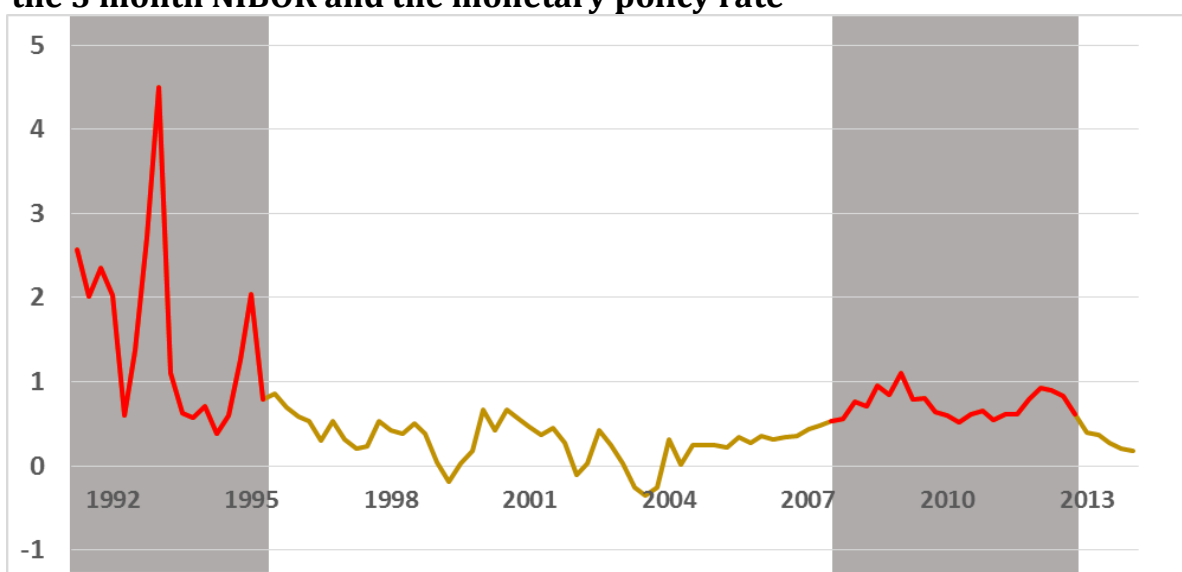


Percent. Sample period: 1991Q2-2013Q2.

The financial turmoil that followed the banking crisis of the late 80's, early 90's, in Norway led to a lot of uncertainty in the market and it should be a fair assumption that the trust between borrower and lender needed to be rebuilt. As far as the trust between lenders and borrowers in the interbank market goes, Figure 8 makes this quite clear. In periods with high financial uncertainty, the market rate (3-month NIBOR) is typically higher than normal over the monetary policy instrument rate. In Figure 8, we see that in periods of financial turmoil or

when coming out of periods with huge financial turmoil (grey areas), lending between banks is done at a large premium over the monetary policy rate. This also makes it easier for banks to both camouflage and justify higher margins on the rates offered to the public. As the dust settled after the banking crisis at the beginning of the 1990's, and the NIBOR came down to normal levels, we see from Figure 7 that the margins also came down and stabilized. This development is also evident in the 2008 financial crisis, but, as we can see, the impact on the risk premium and the margin was far less then.

**Figure 8: The markets risk premium measured as the difference between the 3 month NIBOR and the monetary policy rate**



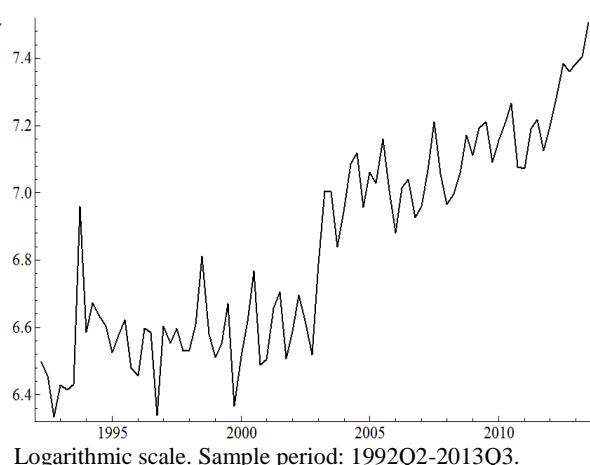
Percent. Sample period: 1991Q2-2013Q3.

This latter evidence suggests that there have been other developments as well. One, which partially occurred due to the crisis ending in the early 1990s, is so-called “flight to quality” in lending (Gilchrist, Bernanke and Gertler, 1994), meaning that the quality of banks’ credit analysis improved greatly. To refer back to the theory on the banks’ premium, increased quality in the credit analysis will result in less lending to borrowers with high agency costs (high  $b$  in Holmström and Tirole) which reduces the credit risk and therefore the margin over banks’ funding cost. The fact that margins came down towards the end of the 1990s, did probably, in addition the regained trust between banks, have something to do with a change in banks’ credit policies. Moreover, while these credit policies were partly changed on banks’ own initiative, due to the losses they faced, they might also be due to the introduction of the Basel reform and capital regulations. Higher quality borrowers also imply a stronger trust between banks in future crises, which along with a more robust banking system, partly explain why we did not get the same impact on the margin and the NIBOR premium in the

2008-crisis. Therefore, Basel I, and its successors, Basel II and III, may have been a factor in dampening the volatility of the margin in later years. In addition, successful refinancing operations, such as exchanging banks' holdings of covered bonds for even more secure government bonds, might also have dampened the impact of the 2008 crisis. In this context, it must be mentioned that the 2008 crisis did not affect the Norwegian financial system all that much, compared to other countries and to the 1980s- 90s banking crisis. Nonetheless, a “flight to quality” should imply that margins from different periods are not directly comparable, as the credit conditions have changed. This will perhaps make the empirical analysis more difficult.

Another possible, or rather joint, explanation for why the interest margin decreases over the period graphed, is that higher productivity in the banking sector has benefitted the customers through lower margins. Figure 9 show that the productivity<sup>22</sup> in banking and other financial institutions has approximately doubled from 1992 to 2013. Developments in technology and general improvements are considered the main drivers behind this increase in productivity (Finance Norway,

**Figure 9: Real productivity in financial services**



2012). As an explanation for decreasing margins, this is also consistent with the findings of Ho and Saunders (1981) and Wong (1997), who analyzed a representative bank and found that a decrease in a bank’s administrative costs also decrease its interest rate margin. In the theory presented in this thesis, one could think of this as a decrease in the monitoring cost.

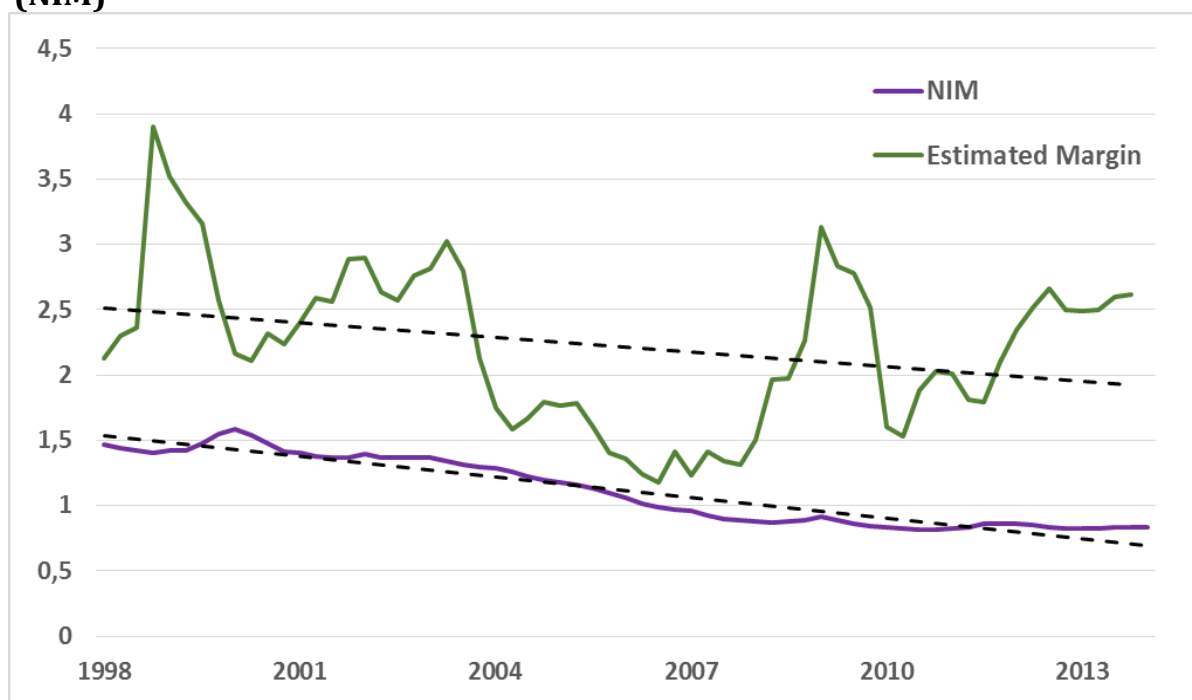
A fourth, and final, explanation is that there has been an increase in bank competition, effectively lowering the interest rate margin. Both the increase in wholesale funding and growth in internet usage, making the process of changing loan provider easier, supports this explanation.

Further evidence, that may support the impact made by changes in the banking sector discussed above, can be found by looking at the net interest margin. Though the NIM does not

<sup>22</sup> Productivity is measured as gross product divided by hours worked

necessarily show any cyclical behavior (as discussed above), it should be affected by the structural changes mentioned. Figure 10 shows this, by comparing the estimated interest margin and the net interest margin over the last 15 years (though it would be interesting to see the full development, balance sheet data going back to 1992 is not available). In the graph, we see that the trend-development in the two measures are almost identical, with the linear trend of the NIM being marginally steeper. This evidence clearly supports the assumed structural changes in the bank market. Furthermore, the negative trends in the margin, lending rate and funding cost might have implications for the estimation undertaken later on, if they are statistically significant. I will however return to this shortly.

**Figure 10: The estimated interest margin and the net interest margin (NIM)**



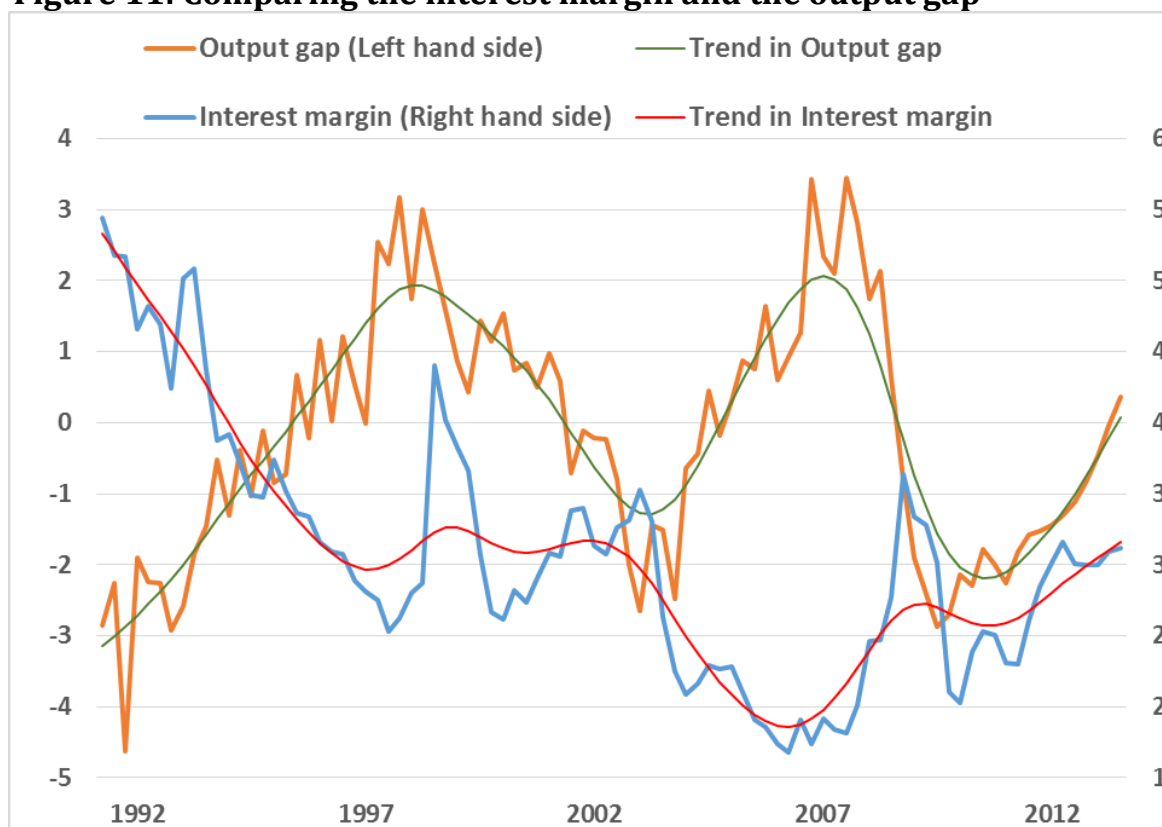
Percent. Sample period: 1998Q1-2013Q3.

Furthermore, and perhaps more interesting, there is a clear difference in the two measures volatility. We see that the estimated interest margin is far more volatile than the net interest margin, and though I have not looked closely at the cyclicity of the estimated margin yet, the graph may imply that, the interest margin is quite efficient in smoothening the banks' net-interest-earnings-to-assets ratio<sup>23</sup>. This is however in light of the story told a few pages back and in Appendix B.

<sup>23</sup> I again refer to Appendix B for a simplified explanation of why this is.

Finally, before moving over to the more hands-on analysis part of this thesis, Figure 11 compares the movements in estimated interest margin with the output gap. At a first glance, we do see that for the most part, and even with the trend in the interest margin, there seems to be opposite movements between the two variables. There are, however, periods where this is not the case and no, at least not valid, conclusions can be made based on these graphs alone. The next couple of chapters will therefore attempt to make this seeming relationship more clear, before any real, confident, conclusions are presented.

**Figure 11: Comparing the interest margin and the output gap**



Percent. Trend variables are HP filtered ( $\lambda = 100$ ). Sample period: 1998Q1-2013Q3.

## 5 Econometric approach to interest margin modelling

To investigate the interesting possibility of countercyclical margins further, and more precisely, I will utilize the econometric methods presented in this chapter. The results of the analyses are discussed in the next chapter. All analysis and data transformation were undertaken in either Oxmetrics (PcGive) or Excel.

### 5.1 Correlation analysis

My, more precise, estimation of the cyclicity of interest margins, starts with a correlation analysis of three different, highly cyclical, variables; the output gap, registered unemployment and the number of bankruptcy estates opened. This approach, except for the difference in variables and lag lengths, is the same used by Kydland and Prescott in their analysis of business cycle movements, see Kydland and Prescott (1990). Here I analyze the correlation of the three typically cyclical variables, including four lags and leads of them, with the interest margin. The lags and leads are included to indicate whether a variable tends to lead or lag the movements in the interest margin. One problem however, is that there are clear signs of non-normality in the variables distributions, so, in order to avoid high Type I error frequencies, I have first converted the variables using a rank-based inverse normal transformation. This method is shown to give good test reliability for non-normal data by, for example, Bishara and Hittner (2012).

### 5.2 Econometric analysis

To support the evidence from the correlation analysis, generate impulse responses, but also as correlation and causation are not the same, I will also estimate an econometric model for the interest margin. In doing so, I will not be using the normally transformed versions of the variables, but the original ones.

The theory in for example Bernanke, Gilchrist and Gertler (1999) tells us that negative shock to the production increases the risk of lending and therefore the lending margin. This will in turn influence total credit and asset prices, reducing investment and further worsening the development in production. By using the output gap, which measures actual production as a

deviation from trend/potential production, the theory suggests that changes in the output gap should affect the interest margin directly, while changes in the interest margin only impact production through credit and investments. Using the output gap as regressor in the equation for the interest margin therefore seems reasonable. However, since one measures the output gap relative to the unobservable, and estimation depended, potential output, I also utilize the cyclicalities found in the unemployment rate in my estimation. The number of bankruptcies is kept out of the picture, in part to keep the system simple, but also since including, the variable gives a far less desirable model in terms of model diagnostics, without given much back in terms of interpretability.

In my regression analysis, I use the two components of the interest margin, the lending rate and the funding cost, to estimate two different equations. This is in part done to be able to get a more complete interpretation from a bank's point of view. The reasoning is that banks typically change their lending rates to respond to changes in the funding cost and not changes in the business cycle directly. The funding cost on the other hand, at least the one specified in this thesis, will respond more directly to changes in the business cycle. This decomposition also gives me one-way granger causality going from funding cost to the lending rate, effectively identifying impulse responses.

The significance of the discussed trend in the variables have been tested with an Augmented Dickey Fuller test. The results, which can be seen in Appendix C, show that there is marginally insignificance of unit roots and slightly significant deterministic trends. With this result in mind, I allow for a deterministic trend in my equations. Knowing that the variables are at least difference stationary, I formulate a ECM model, which would have been used in any case due to its other desirable properties, for example the distinction between the short-term dynamics and the variables that drive the estimated long-run relationship. The two general ECM equations are specified as follows:

$$\Delta FC_t = \alpha_0 + \alpha_1 FC_{t-1} + \sum_{j=1}^k \alpha_{j+1} \Delta FC_{t-j} + \omega_1 X_{t-1} + \sum_{i=0}^{k+1} \omega_{2+i} \Delta X_{t-i} + D_2 + \mu_2 T + \varepsilon_{2,t}$$

$$\Delta i_t^L = \beta_0 + \beta_1 i_{t-1}^L + \sum_{j=1}^k \beta_{j+1} \Delta i_{t-j}^L + \gamma_1 FC_{t-1} + \sum_{i=0}^{k+1} \gamma_{i+2} \Delta FC_{t-i} + D_1 + \mu_1 T + \varepsilon_{1,t}$$



Where  $i^L$  is the lending rate,  $FC$  the funding cost and  $X$  represent the business cycle components; the output gap and unemployment rate.  $D$  holds different dummy variables, which are established by PcGive through the Autometrics algorithm (Doornik and Hendry, 2013, pg. 220) and  $T$  is a deterministic trend variable.

Since it seems realistic that the data contains structural breaks and outliers, there is reason to use Autometrics' dummy saturation (letting PcGive select indicator variables) in order to obtain Robust OLS estimates, see Johansen and Nielsen (2008). In doing so, I adopt a conservative approach to avoid excessive indicators, and set the target p-value size in Autometrics to 0.01.

Even though banks in Norway are not allowed to change the interest rates (on existing loans) before first giving their customers six weeks' notice (The Norwegian Law of Financial Agreements, 1999), the contemporaneous funding cost difference is not omitted from the model. One reason for this is that banks typically, though they are not restricted to by law, also wait six weeks to change deposit rates (Fidjestøl, 2009). In light of this and since there also are forward and future contracts available for currency loans, it is assumed that banks are able to correctly forecast the contemporaneous funding cost.

Since I am working with quarterly data, I start the general model out with four lags of each variable (Davidson and MacKinnon, 2004, pg. 578). In moving towards a more parsimonious model, I have instructed the Autometrics algorithm to keep enough lags of the lending rate and the funding cost, to avoid autocorrelation. I also restrict the variables needed to obtain a valid ECM mechanism (the first lag of the level variables). All other variables and lags are omitted if found insignificant.

# 6 Results

## 6.1 Results of correlation analysis

After having transform the variables, as discussed in section 5.1, Table 5 shows the correlation between the cyclical variables and the interest margin from 1992-2012. The blue shade indicates which lead or lag has the highest, in absolute value, correlation with the interest margin. A t-value, indicating the degree of significance, is listed right below the coefficient. Here, values higher than 1.665<sup>24</sup>, again in absolute value, are significant at the 5% level, which only leaves a few lags of the output gap and bankruptcies, insignificant (red shade).

<b>Table 5: Correlation analysis</b> <i>Sample period: 1992Q2-2012Q3.</i>									
	<i>t-4</i>	<i>t-3</i>	<i>t-2</i>	<i>t-1</i>	<i>t</i>	<i>t+1</i>	<i>t+2</i>	<i>t+3</i>	<i>t+4</i>
<b>Output gap</b>	-0,156	-0,176	-0,246	-0,290	-0,383	-0,421	-0,448	-0,417	-0,326
<b>t-value</b>	-1,436	-1,632	-2,308	-2,765	-3,772	-4,229	-4,566	-4,182	-3,138
<b>Unemployment</b>	0,239	0,245	0,268	0,339	0,429	0,522	0,627	0,695	0,747
<b>t-value</b>	2,241	2,301	2,536	3,282	4,328	5,582	7,329	8,797	10,222
<b>Bankruptcies</b>	0,165	0,195	0,316	0,355	0,399	0,420	0,390	0,360	0,311
<b>t-value</b>	1,526	1,810	3,030	3,456	3,960	4,222	3,857	3,512	2,980

The result are very interesting in the light of the theoretical discussion above. First, we see that the output gap is negatively correlated with the margin, which is a direct proof of a countercyclically interest margin. The significance of the contemporaneous coefficient and its absolute value (or power) is quite high, which is a good sign. Moreover, the two remaining variables are, not surprisingly, positively correlated with the interest margin. This is not surprising as the number of unemployed and firms going bankrupt typically rise as the business cycle contracts.

Evidently, only looking at the contemporaneous variables coefficients, all three are significantly high enough to say that the interest margin has countercyclical movements.

<sup>24</sup> As suggested from a table of critical values of the t-distribution given 90 degrees of freedom.

Interestingly, all the variables are seemingly also lagging the interest margin (i.e. the interest margin peaks first). Since the interest margin is assumed to only influence production through changes in credit, this seems reasonable. Also, from a monetary policy point of view, changes in the monetary policy rate will typically be done to control inflation, avoid financial imbalances and smooth the course of the business cycle (flexible inflation targeting) (Norges Bank, 2013 (1)). This in turn implies that when Norges Bank change the monetary policy rate, which should have direct effects on the banks funding cost, their goal, at least to some extent, is to revert the business cycle back to trend.

## **6.2 Results of econometric analysis**

The econometric model discussed in section 5.2 aims, from a theoretical perspective, at utilizing the correlation between the contemporaneous and lagged levels of the cyclical variables and the margin, to give support to the margins role in the financial accelerator framework.

The estimated equations are shown in Table 6, while graphs of the actual and fitted values are found in Figure 12 (the corresponding residuals can be found in Appendix D).

The first thing to notice from Table 6, is that neither of the equations have a deterministic trend in them. Possible explanations for this is that the dummy variables control for the negative trend seen in the regressands and also that there might be a common trend between the funding cost and the lending rate in that equation. In addition, we note that omission of the trend makes the model more suitable for forecasting, as having a linear trend would give a negative and still decreasing margin at some point in the future, which of course is not realistic. Also, note that the included dummies seem to be interpretable in the light of known historical events in the sample period.

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**Table 6: The results of estimation**

*Sample period: 1992Q4-2013Q3. Both equations were reduced and estimated individually by Robust OLS. The system is estimated using FIML.*

*Abbreviations: FC = Funding cost,  $i^L$  = Average lending rate, OG = Output gap, U = Seasonally adjusted unemployment rate<sup>25</sup>.*

*Numbers in parenthesis are std. errors.*

**The funding cost equation:**

$$\begin{aligned} \Delta FC_t = & 0.353 - 0.051 FC_{t-1} + 0.082 OG_{t-1} - 0.06 U_{t-1} + 0.408 \Delta FC_{t-1} \\ & (0.09) \quad (0.017) \quad (0.018) \quad (0.027) \quad (0.053) \\ - & 0.27 \Delta FC_{t-2} + 0.11 \Delta OG_t + 1.057 D1992(4) - 1.27 D1993(1) + 0.63 D1995(2) \\ & (0.05) \quad (0.03) \quad (0.23) \quad (0.235) \quad (0.2) \\ - & 0.56 D1997(4) + 1.48 D1998(3) + 0.69 D2000(3) - 0.57 D2003(1) - 0.75 D2003(3) \\ & (0.2) \quad (0.2) \quad (0.19) \quad (0.2) \quad (0.2) \\ - & 1.21 D2008(4) - 0.97 D2009(1) + 0.9 D2009(4) + \epsilon_{FC,t} \\ & (0.2) \quad (0.22) \quad (0.21) \end{aligned}$$

**The lending rate equation:**

$$\begin{aligned} \Delta i_t^L = & 0.28 - 0.141 i_{t-1}^L + 0.15 FC_{t-1} + 0.39 \Delta i_{t-1}^L - 0.07 \Delta i_{t-2}^L + 0.52 \Delta FC_t \\ & (0.06) \quad (0.034) \quad (0.05) \quad (0.05) \quad (0.03) \quad (0.05) \\ + & 2.3 D1998(3) - 1.16 D1998(4) + - 0.76 D2003(3) - 0.78 D2009(1) \\ & (0.16) \quad (0.23) \quad (0.14) \quad (0.15) \\ + & 0.48 D2009(2) - 0.35 D2009(4) + \epsilon_{iL,t} \\ & (0.15) \quad (0.15) \end{aligned}$$

**System diagnostics**

Vector SEM-AR 1-5 test:  $F(20,116) = 0.64427$  [0.8711]

Vector Normality test:  $\chi^2(4) = 0.95369$  [0.9167]

Vector Hetero test:  $F(54,176) = 1.0754$  [0.3554]

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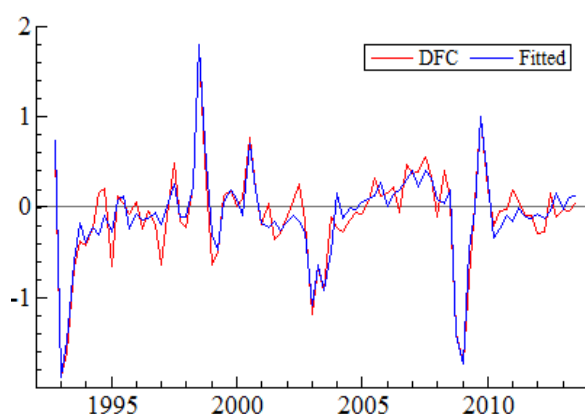
The graphs in Figure 12 show that the actual and fitted values are relatively close. Note in particular that there is no systematic tendency that the fitted values lag behind the actuals. This is proof that the variation in the exogenous and pre-determined variables are important for the fit, and not only the lagged values of the left hand side variable.

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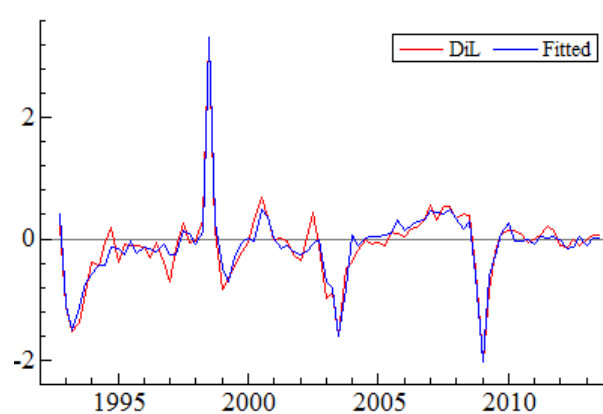
<sup>25</sup> Seasonally adjusted using PcGive's X12Arima extension (U.S Consensus Bureau, 2011).

**Figure 12: Actual and fitted values**

*Funding cost:*



*Lending rate:*



Moving on, we see that the coefficients of the first equation point to a procyclical funding cost since the output gap has a positive impact while the unemployment rate has a negative impact. In normal times, this is also quite intuitive. NIBOR is traditionally fixed at a small premium over the monetary policy instrument rate, which is typically procyclical. The deposit rate, which accounts for the main part of the banks funding costs, will follow NIBOR at a discount. In addition, the bank can afford to pay out more to their investors when times are good. However as discussed in the former section, there are also situation where NIBOR might be exceptionally high over the instrument rate. This will typically be in situations with large unexpected negative shifts in production (positive shifts in unemployment). In these situations, we might see positive shifts in the funding cost even though there are negative shifts in the business cycle, due to uncertainty in the market. These situations do however not disrupt the model to any large extent, since they are controlled for by the indicator variables.

Having pinned down the procyclical movement in the funding cost we move over to the lending rate equation. A first note is that the contemporaneous funding cost (1. difference) is significant in this equation. Moving on, we see that the lending rate increase with the funding cost as expected. The interesting thing to notice is however that following an increase in the funding cost, the lending rate increase with less, leaving us with a smaller margin. This it at least true in the short-run, while the long-term error correction mechanisms give a different effect.

Therefore, in light of the long-term implications of the error correction terms, but also an omitted variable assumed to have numerical significance, I will make some final alterations to

the model, that deserves commenting, before making any further assumptions regarding business cycle originating shocks. Specifically, I will force the first difference of the unemployment level back into the model. This is due to the variables assumed numerical significance, which implies that looking at the impulse responses as-is, would grossly underestimate the impact on the funding cost and therefor the margin<sup>26</sup>. Also in light of economic theory, the correlation analysis in chapter 5 and the graph of the output gap and the interest margin in Figure 11, some alteration to the long-term relationships are justified. The error correction terms from Table 6 are:

$$ECM_t^{FC} = FC_t + \left( \frac{0.082}{-0.051} \right) OG_t + \left( \frac{-0.06}{-0.051} \right) U_t = FC_t - 1.61 OG_t + 1.18 U_t$$

$$ECM_t^{iL} = i_t^L + \left( \frac{0.15}{-0.141} \right) FC_t = i_t^L - 1.06 FC_t$$

$ECM_t^{iL}$  shows that the point estimate of the long-run coefficient of the funding cost is larger than one, indicating that the lending rate increases more than the funding cost to correct for imbalances. This implies long-term procyclical tendencies in the margin following shocks to the business cycle, which is contradictory to the theory and the previous evidence from this thesis. Therefore, since the theoretically most reasonable parameter in  $ECM_t^{iL}$  is less than one, and since a 95% confidence interval for this parameter<sup>27</sup> suggests that significant values also include values down to 0.89 (from the original 1.06), I will adopt a parameter lower than one<sup>28</sup>. Specifically, I adopt the value 0.9, which is inside the 95% confidence interval. Consequently, the theoretically justified, change in the error correction mechanism in the lending rate equation becomes:

$$ECM_t^{iL} \rightarrow ECM_t^{iL*} = i_t^L - 0.9 FC_t$$

<sup>26</sup> This does however only influence the size and not the direction of the shock.

<sup>27</sup> The delta method gives me the standard deviation of the parameter in  $ECM_t^{iL}$  as ( $\sigma$  used for std. deviation and covariance as in (Bårdsen and Nymoen, 2011)):

$$\sqrt{Var\left[\frac{X}{Y}\right]} \approx \sqrt{\left(\frac{1}{\mu_Y}\right)^2 [\sigma_X^2 + \left(\frac{\mu_X}{\mu_Y}\right)^2 \sigma_Y^2 - 2 \left(\frac{\mu_X}{\mu_Y}\right) \sigma_{X,Y}]}$$

$$= \sqrt{\left(\frac{1}{-0.141}\right)^2 [0.045^2 + \left(\frac{0.15}{-0.141}\right)^2 0.0342^2 - 2 \left(\frac{0.15}{-0.141}\right) (-0.0015)]} \approx 0.089$$

Using this standard deviation to calculate a 95% confidence interval for the parameter in  $ECM_t^{iL}$  gives a confidence interval between  $1.06 \pm 0.089 * 1.96$ , i.e. roughly between 0.89 and 1.23.

<sup>28</sup> A brief review of the implications of not altering the ECM term is given at the end of the chapter.

Together with the first difference in the unemployment rate, we get the structure shown in Table 7, excluding indicator variables for ease of reading.

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**Table 7: The results of estimation with contemporaneous unemployment<sup>29</sup>**

*Sample period: 1992Q4-2013Q3. The system is estimated using FIML.*

*Abbreviations: FC = Funding cost,  $i^L$  = Average lending rate, OG = Output gap, U = Seasonally adjusted unemployment rate<sup>30</sup>, ECM = The error correction mechanisms.*

*Numbers in parenthesis are std. errors.*

**The funding cost equation:**

$$\Delta FC_t = 0.325 - 0.049 ECM_{t-1}^{FC} + 0.41 \Delta FC_{t-1} - 0.26 \Delta FC_{t-2} + 0.11 \Delta OG_t - 0.18 \Delta U_t$$

(0.07) (0.008) (0.05) (0.05) (0.027) (0.17)

$$+ D + \epsilon_{FC,t}$$

**The lending rate equation:**

$$\Delta i_t^L = 0.27 - 0.10 ECM_{t-1}^{iL} + 0.425 \Delta i_{t-1}^L - 0.072 \Delta i_{t-2}^L + 0.5 \Delta FC_t + D + \epsilon_{iL,t}$$

(0.06) (0.02) (0.05) (0.03) (0.05)

***System diagnostics***

Vector SEM-AR 1-5 test:  $F(20,118) = 0.51036 [0.9577]$

Vector Normality test:  $\chi^2(4) = 0.61213 [0.9617]$

Vector Hetero test:  $F(66,165) = 1.0662 [0.3664]$

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Using the VECM in Table 7, I calibrate the impulse responses in Figure 13 so that they respond to a 1 percent negative shock in unemployment.

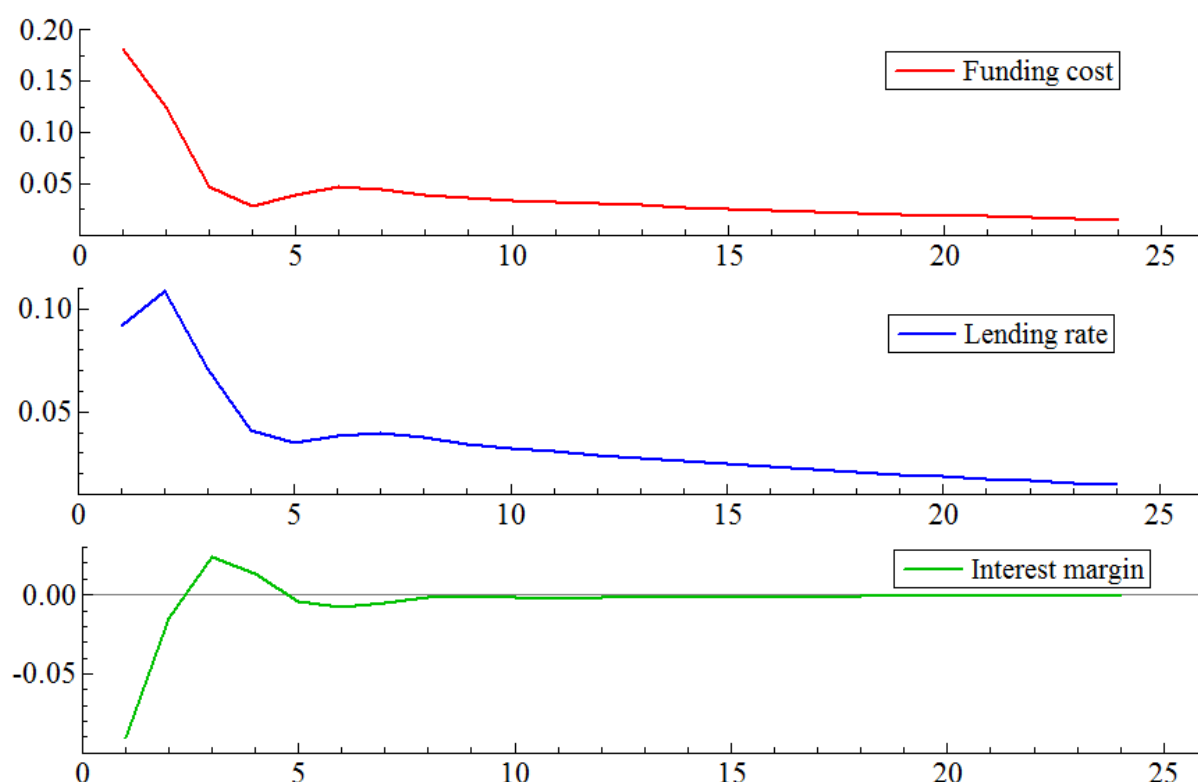
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<sup>29</sup> ECM's might be slightly different than the one expected from Table 6 due to rounding errors and effects of DU.

<sup>30</sup> Seasonally adjusted using PcGive's X12Arima extension (U.S Consensus Bureau, 2011).

**Figure 13: Impulse responses following a negative unit shock to unemployment**

*Based on the system in Table 7.*



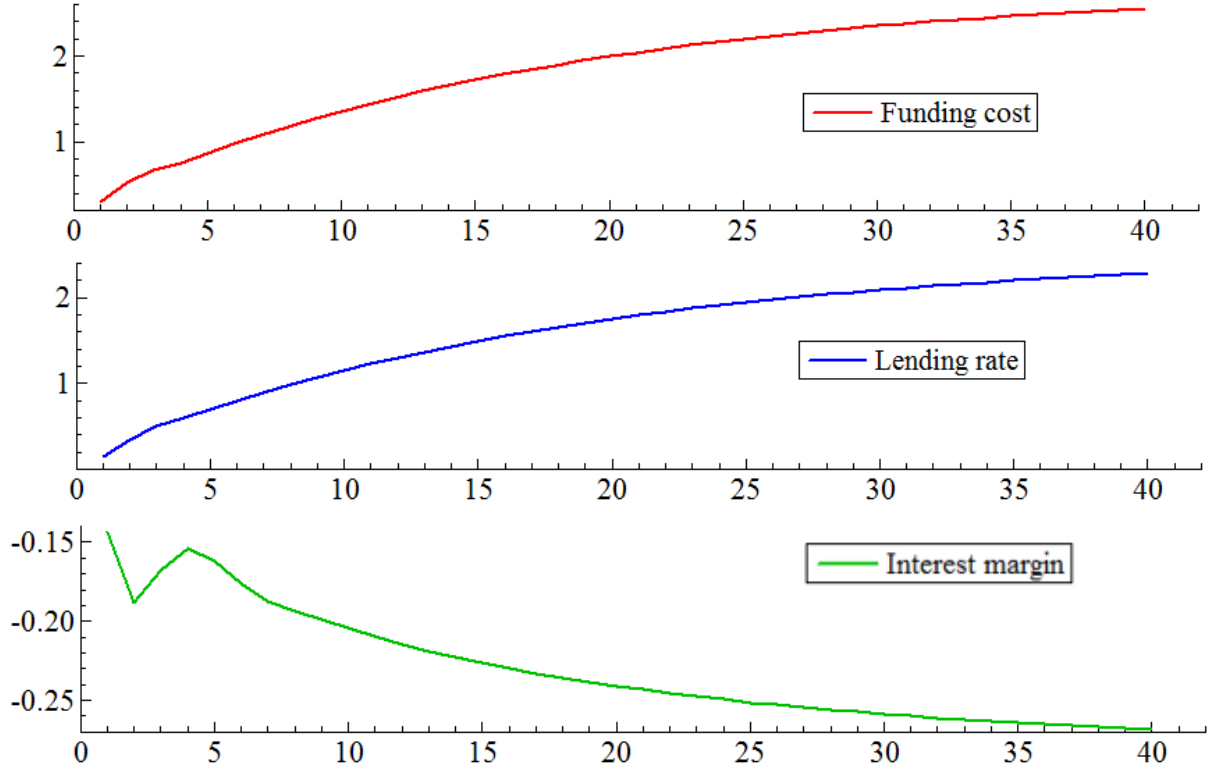
Since the unemployment rate is exogenous in the model, and therefore has no dynamics, the shock dies out fairly quickly. Therefore, it is interesting to see that even in light of this short shock to unemployment, the interest margin shows countercyclical tendencies. It should however be a fair assumption that banks do not react as they might have done following consecutive shock to the unemployment rate, more alike the business cycles up and downs.

In order to create more relevant impulse responses, better explaining the responses to business cycle movements, I have also included the impulse responses in Figure 14. These graphs show the response in the funding cost, lending rate and interest margin, to lasting, one unit, simultaneous shocks to unemployment (negative) and the output gap (positive). The joint shock is relevant since it is unlikely that the unemployment rate would change without this having implications for production as well. The one to one relationship is however not necessarily realistic. Again, I urge readers not to be fooled by the lack of dynamics, the interest margin would have reverted back to its original value, had the shock to the business cycle lessened and disappeared.



**Figure 14: Impulse responses following a permanent negative unit shock to unemployment and a permanent positive unit shock to the output gap.**

*Based on the system in Table 7.*



With the joint shock, the negative effect in the margin is very clear and quite large (25 basis points after 6 years and decreasing). With these results, and the results from the correlation analysis in part 6.1, the overall conclusion, with the restrictions made, is that countercyclical movements in the banks interest margin is to be expected. These results therefore follow the theoretical results of Holmström and Tirole (1997) and Bernanke, Gilchrist and Gertler (1999) and might help explain the link between the financial -and real sector of the economy.

Finally, to see the impact of changing the  $ECM^{iL}$  equation and as it provides us with an interesting alternative, especially when connected to results from H&J, I will briefly review the impulse responses generated from a system with contemporaneous unemployment and the original  $ECM^{iL}$  term:

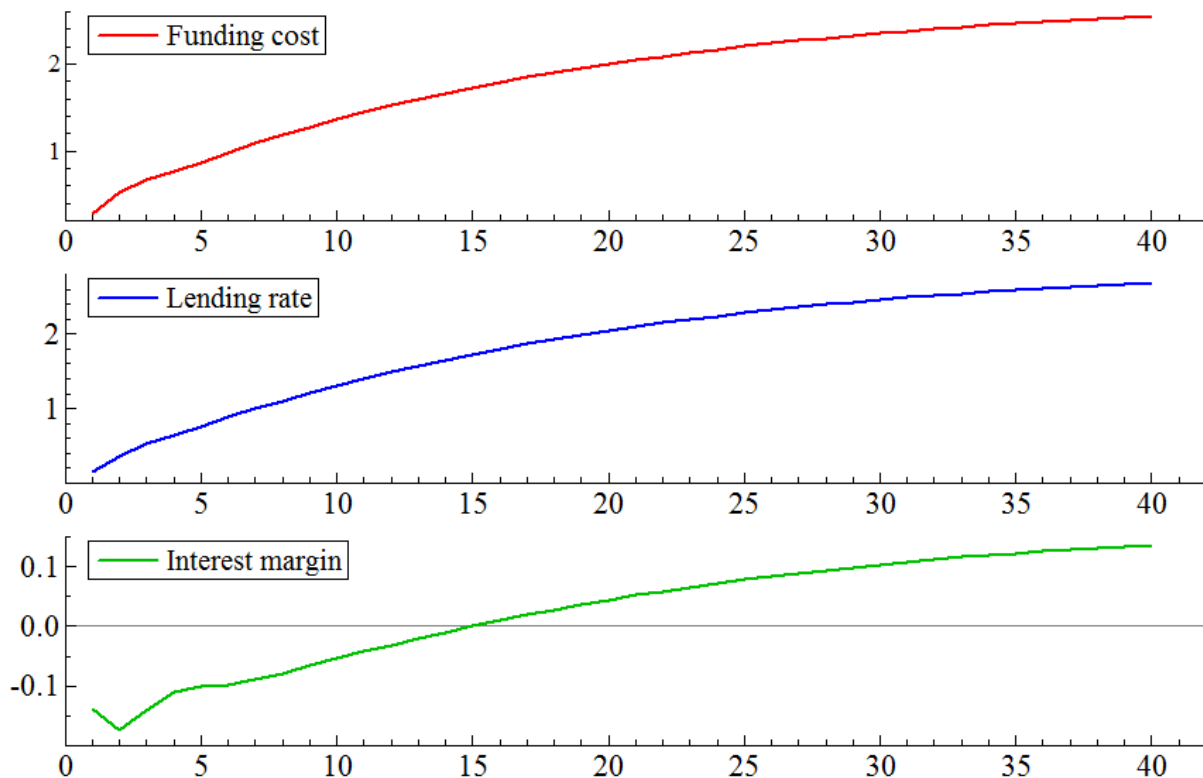
$$ECM_t^{iL} = i_t^L - 1.06 FC_t.$$

A table of the estimation results and system diagnostic of this system can be found in Appendix D.

Using this specification, the following impulse responses are generated in the same way as in Figure 14 (a permanent shock to both unemployment and the output gap).

**Figure 15: Impulse responses following a permanent negative unit shock to unemployment and a permanent positive unit shock to the output gap.**

*Based on the system in Appendix D, with non-altered ECM terms.*



Looking at the interest margin's reaction now, it is quite different, as one should expect following the discussion of the ECM terms. Before commenting any further, I would like readers to note, that due to lack of dynamics here, the following discussion is merely an observation, or a possibility, and not decisive evidence (if such even exist in econometric modelling). First, and foremost, the margin is, as mentioned in the description of the results in Table 6, still countercyclical. However, following persistent or repetitive shocks to the business cycle, the margin's error correction mechanism will eventually take over and slowly revert it beyond its original level. Remembering that one of the results of H&J was that there were seemingly no long-term financial accelerator effects, the impulse responses in Figure 15 may help explain why a significant procyclical long-run connection between asset prices, credit and production can be hard to detect empirically.

## 7 Concluding remarks

In this thesis, I have made use of the results and concepts of the literature on the financial accelerator and interest margins to examine the counter cyclicalities of banks' interest margins. I began with a rather full reproduction of the financial accelerator evidence provided by Hammersland and Jacobsen (2008) before I shifted focus over to the interest margin. First, I operationalized the banks' funding cost through a weighted average cost of capital approach and used this to define a seemingly realistic interest margin for banks. I then looked at the development in this margin and made some interesting observations. Furthermore, using the defined margin, I analyzed its correlation with typical cyclical variables and then estimated an econometric model for the banks' lending rates and funding costs.

The results from the reconstruction imply that there may exist a financial accelerator in the Norwegian economy, but the results are not as convincing as the ones found in the original paper. For one, my results show that letting the data speak freely by adopting a model designed by a strict general to specific (GETS) method, actually refutes the existence of a financial accelerator, even in the short run. However, the model design through a strict GETS approach was not completely satisfactory in terms of realism. On the other hand, a model designed as in H&J, while realistic in the directions of the coefficients, also gave less significant ones, and in addition, econometric system diagnostics that were less convincing than in the original research-paper.

The results of both the correlation analysis and the estimated system of the interest rate margin, indicate that the banks tend to increase their margins as the business cycle takes a negative turn, which is to say that the interest margin is countercyclical. This result is in line with the financial accelerator theory, especially that of Bernanke, Gilchrist and Gertler (1999), and help explain some of the procyclicality that is typically found in credit provision.

In the thesis, there was also an additional observation made, on the development in the net interest margin (NIM). The development in the NIM, which is a measure of banks' return on available assets (assets available for lending), has been far less volatile than the estimated interest margin's. Since the NIM accounts for changes in credit, expected losses, actual losses and non-performing assets, countercyclical movements in the interest margin might just be the mechanism that evens out the NIM over time. If this is true, it enhances the realism of,

and gives further reasoning for, the cyclical movements in the interest margin. Note that nothing is said about the effects on actual bank earnings, for which the effects of countercyclical margins, should be analyzed further.

However, even though the results are quite conclusive and reasonable, several comments and caveats can be made about my modelling approach. For example, when operationalizing the funding cost of banks, my measure was chosen because it seemed more realistic, but as several assumptions were made and proxies were used, the validity of the measure must be taken into question. That said, simply using the deposit rate, as is popularly done, gives similar results and conclusions as far as the cyclicity of the margin goes. Moreover, some fine-tuning of the econometric model was necessary to get realistic long-run results in line with theory and the result from the correlation analysis. The changes made were however also statistically valid.

Moving on, it should be noted that the results might even have policy implication regarding bank regulation as a way to dampen the procyclicality of credit and asset prices. If we – as a thought experiment - assume that banks' margins can be regulated directly, dampening the cyclicity of margins should also affect credit and therefore reduce the financial accelerator effects. Interestingly, a countercyclical buffer was introduced in Norway in the fall 2013<sup>31</sup>. The purpose was to reduce banks' tightening of credit in economic downturns. This buffer requires banks to hold more core capital when times are good, and funds can be made available as the business cycle turns. Norges Bank, advising the Norwegian Ministry of Finance on the appropriate level of this buffer, have made the following statement regarding the intended function of the buffer:

*“Banks shall build up and hold a countercyclical capital buffer when financial imbalances are building up or have built up over a period. The buffer rate can be reduced in the event of an economic downturn and large bank losses. If the buffer functions as intended, banks will tighten lending to a lesser extent in a downturn. This may mitigate possible procyclical effects of banks' lending practice”* (Norges Bank, 2013 (2))

Therefore, if the buffer works as intended, one might expect to see less cyclicity in the banks' margins in the future, even though it is not the primary intention.

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<sup>31</sup> By law - the buffer is not effectively in place before the beginning of 2015.

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# Appendix

## Appendix A

### Appendix A.1

**Table AA.1: The final structure of Hammersland and Jacobsen (2008)**

$$\begin{aligned}
 & \begin{pmatrix} 1 & -0.15 & 0 \\ (0.079) & & \\ -0.58 & 1 & -0.075 \\ (0.17) & & (0.035) \\ 0 & -1.3 & 1 \\ & (0.33) & \end{pmatrix} \begin{pmatrix} \Delta gdp_t \\ \Delta c_t \\ \Delta s_t \end{pmatrix} = \begin{pmatrix} -0.51 & 0 & 0 \\ (0.074) & & \\ 0 & -0.15 & 0 \\ & (0.09) & \\ 0.75 & 0.44 & 0.46 \\ (0.21) & (0.26) & (0.086) \end{pmatrix} \begin{pmatrix} \Delta gdp_{t-1} \\ \Delta c_{t-1} \\ \Delta s_{t-1} \end{pmatrix} \\
 & + \begin{pmatrix} -0.16 & 0 & 0 \\ (0.05) & & \\ 0.38 & -0.041 & 0 \\ (0.083) & (0.0075) & \\ 0 & 0 & -0.201 \\ & & (0.037) \end{pmatrix} \begin{pmatrix} gdp - 0.0073 \text{ TREND} \\ c - s \\ s - 0.26 \text{ poil} - 0.01 \text{ TREND} \end{pmatrix}_{t-1} \\
 & + \begin{pmatrix} 0 & 1.93 & -0.053 & -0.094 & -0.066 & 0 & 0 \\ (0.60) & (0.007) & (0.006) & (0.005) & & & \\ -0.047 & -4.05 & 0.057 & 0.056 & 0.033 & -0.069 & 0.066 \\ (0.0167) & (0.97) & (0.016) & (0.014) & (0.0125) & (0.02) & (0.02) \\ 0.164 & 0.687 & 0 & 0 & 0 & 0 & 0 \\ (0.06) & (0.126) & & & & & \end{pmatrix} \begin{pmatrix} \Delta \text{poil}_t \\ 1 \\ S1_t \\ S2_t \\ S3_t \\ D1991Q4_t \\ D1992Q4_t \end{pmatrix} \quad (5) \\
 & + \begin{pmatrix} 0.06 & 0 & 0 & 0 & -0.04 \\ (0.014) & & & & (0.009) \\ 0 & 0.08 & 0 & 0 & 0 \\ & (0.02) & & & \\ 0 & 0 & -0.28 & -0.18 & 0 \\ & & (0.073) & (0.074) & \end{pmatrix} \begin{pmatrix} D1986Q2_t \\ D2000Q3_t \\ D1987Q4_t \\ D1992Q3_t \\ D1997Q2_t \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{pmatrix}
 \end{aligned}$$

#### System diagnostics and test of restrictions

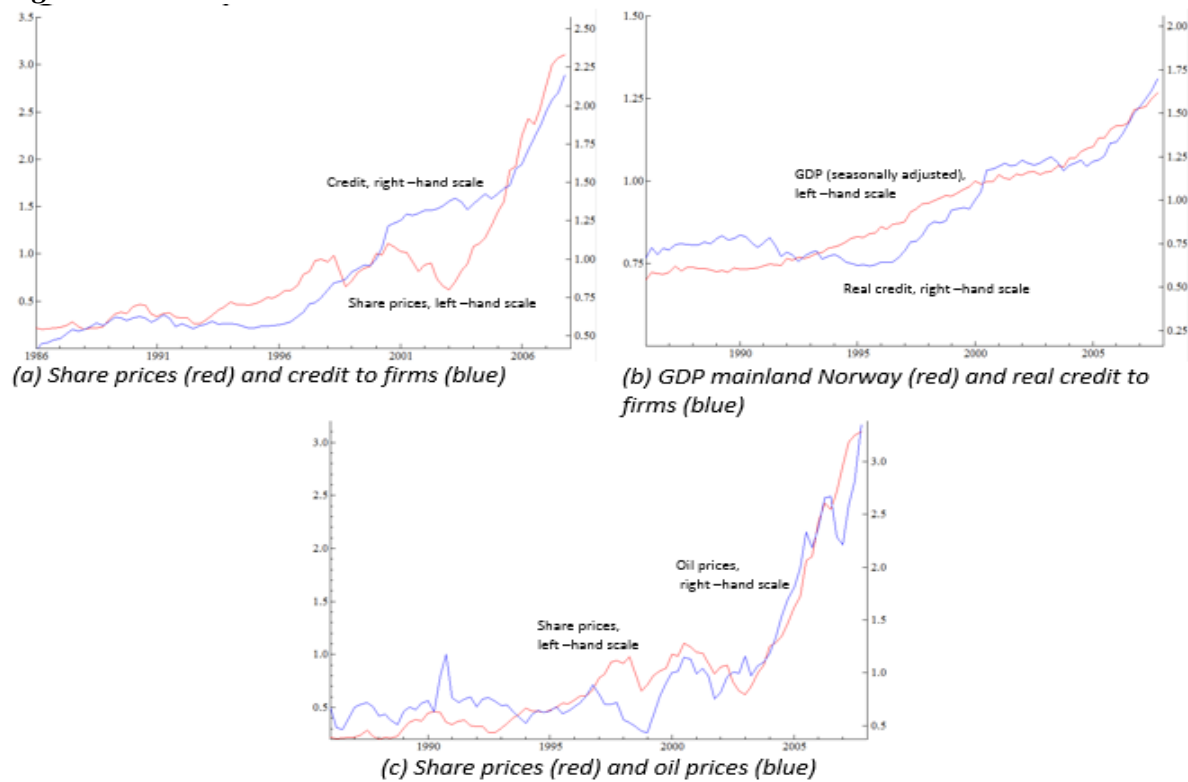
LR-test for over-identifying restrictions:	$\chi^2(38)$	=	42.497[0.2835]
Vector test for autocorrelation of order 1-5:	F(45, 164)	=	0.7368[0.8843]
Vector test for normality:	$\chi^2(6)$	=	7.111[0.3107]
Vector test for heteroscedasticity:	F(198, 203)	=	0.73695[0.9843]



## Appendix A.2

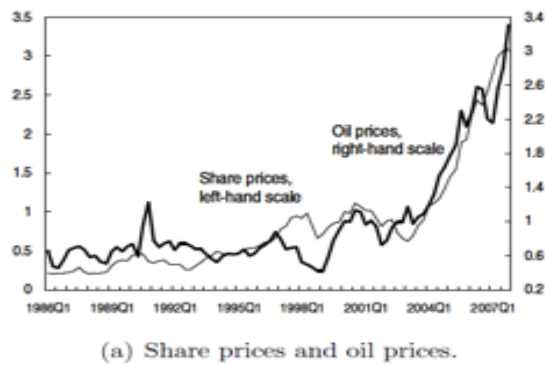
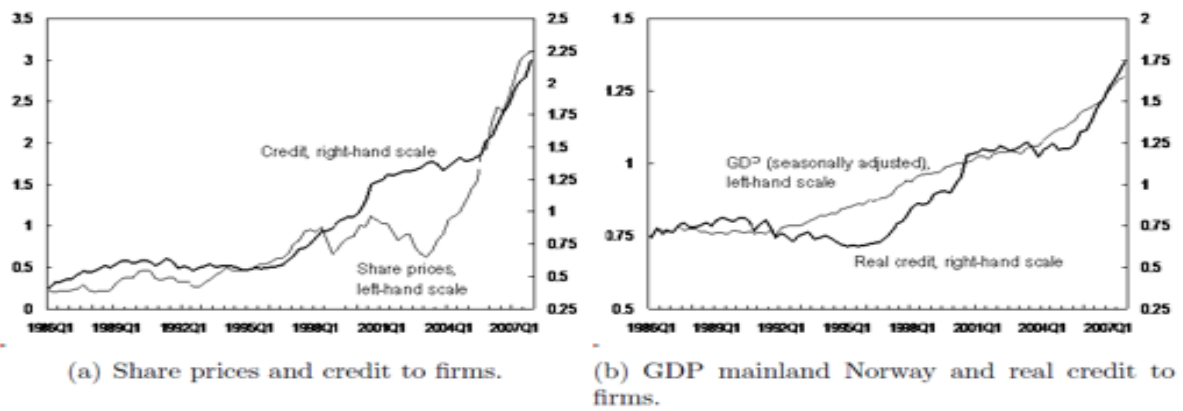
### Figure AA.2: Comparable graphics

*Figure AA.2a: The variables used in this reconstruction*



Indices, 2000Q1=1. Sample period: 1986Q1-2007Q4

*Figure AA.2b: The variables used in Hammersland and Jacobsen (2008)*



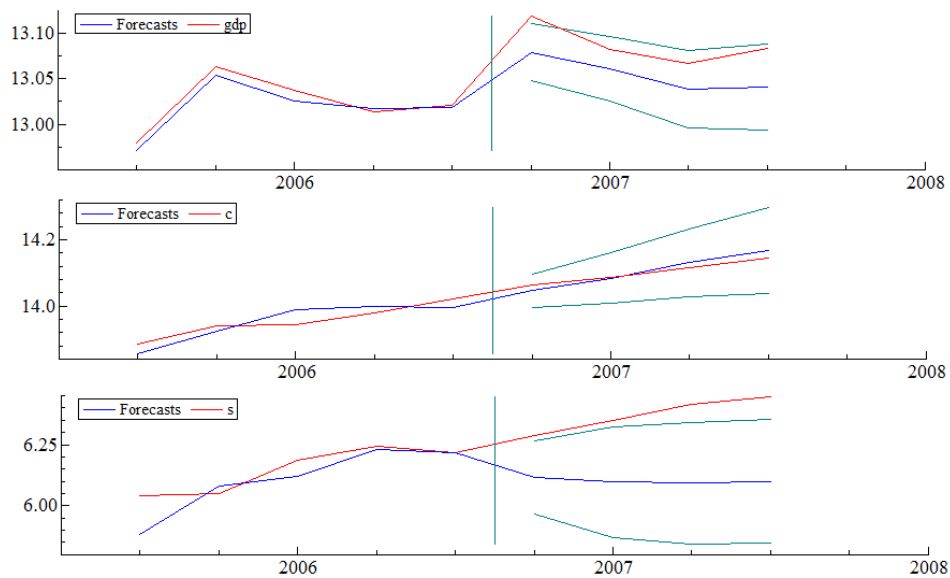
Indices, 2000Q1=1. Sample period: 1986Q1-2007Q1

## Appendix A.3

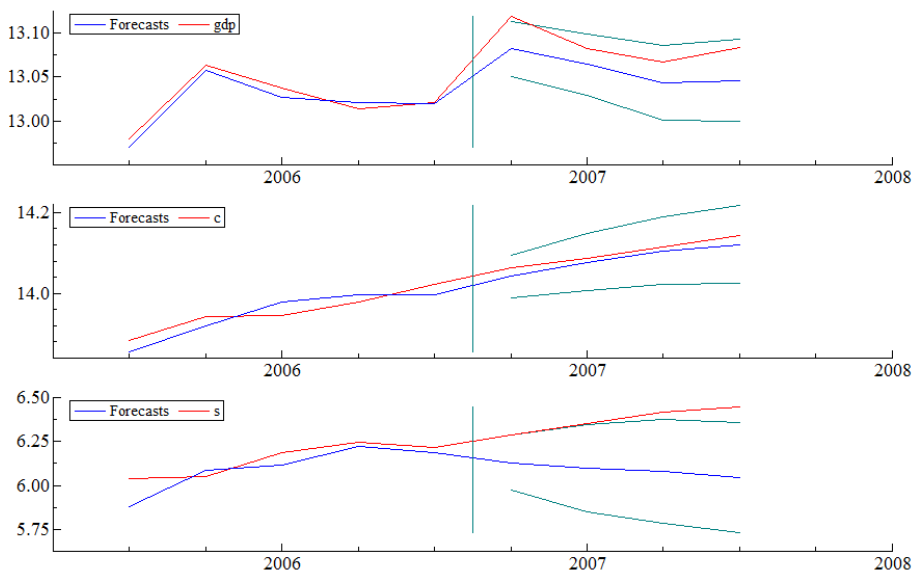
### Figure AA.3: Forecasts

Forecasting from 2006Q4 to 2007Q3

*Strict GETS method:*



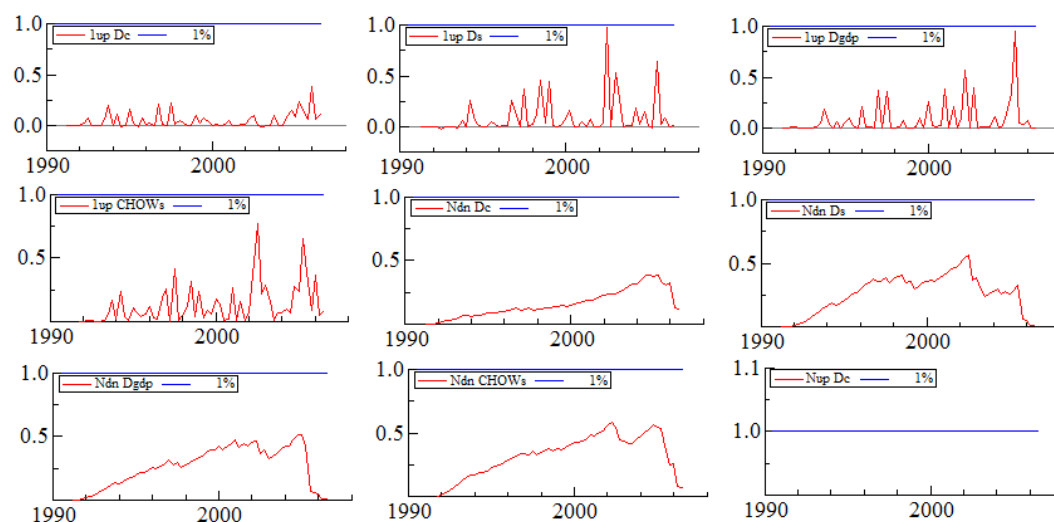
*Using Hammersland and Jacobsen's model:*



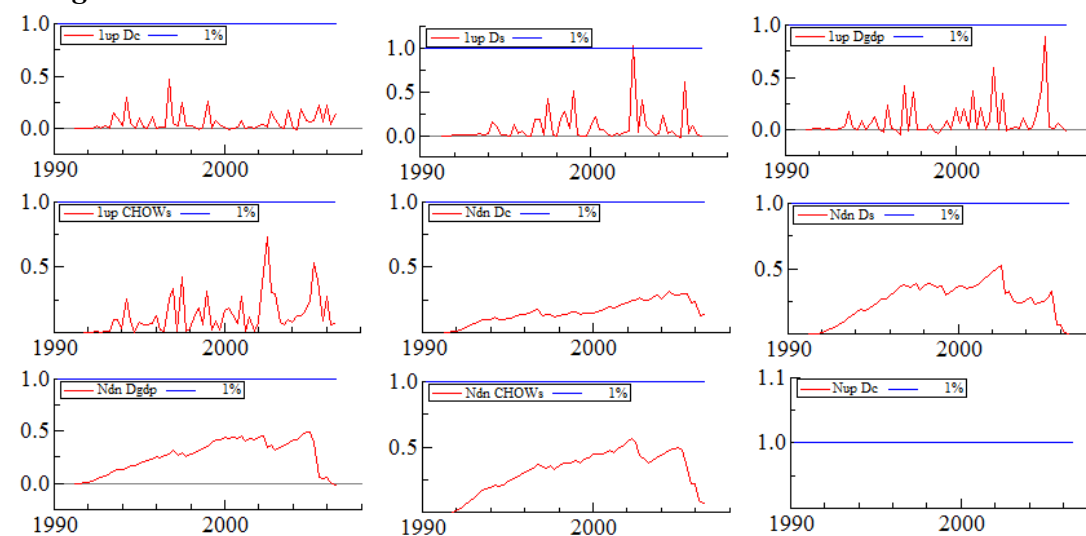
## Appendix A.4

Figure AA.4: Stability tests

*Strict GETS method:*



*Using Hammersland and Jacobsen's model:*



## Appendix B:

### A very stylized example of the non-cyclical of banks' net interest margin under the hypothesis of a countercyclical nominal interest margin

Assume that first the economy is in a good state where the lending rate is 10% the deposit rate is 5% and total credit (or total assets) is 100. The ratio of non-performing assets (NPA) is 0%.

We then get the following NIM:

Lending rate	Deposit rate	Credit	NPA	Calculation	Net interest margin
10	5	100	0%	$\frac{10 * (100 * 1) - 5 * 100}{100}$	5

Assume next that the business cycle turns and that credit contracts to 90. Following the bad times, the ratio of NPA increases to 11% and that the margin, which is countercyclical by assumption, increases from 5% to 6% after a 100 basis point drop in the lending rate and a 200 basis point drop in the deposit rate:

Lending rate	Deposit rate	Credit	NPA	Calculation	Net interest margin
9	3	90	11%	$\frac{9 * (90 * 0.89) - 3 * 90}{90}$	5

So even with the change in the margin, the NIM, and therefore the rate the banks' get from the funds it has available, stays constant.

This is however, only one possible explanation, firmly adopted to fit the story told in the main text of this thesis. Finding evidence of this relationship is not a part of this thesis.

## Appendix C:

**Table AC: Unit root tests and significance of time trend in the average lending rate and the funding cost.**

*Abbreviations: FC=Funding cost, iL=Lending rate. D imply differences.*

### ***Unit-root tests – with constant***

The sample is: 1992(4) - 2013(3) (90 observations and 2 variables)

iL: ADF tests (T=84, Constant; 5%=-2.90 1%=-3.51)

D-lag	t-ADF	beta	Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
5	-3.305*	0.91419	0.5224	-0.5822	0.5621	-1.219		
4	-3.361*	0.91328	0.5202	0.1761	0.8607	-1.239	0.5621	
3	-3.378*	0.91364	0.5170	0.04598	0.9634	-1.262	0.8316	
2	-3.403*	0.91371	0.5137	-1.233	0.2213	-1.286	0.9457	
1	-3.598**	0.90937	0.5154	5.209	0.0000	-1.291	0.7646	
0	-3.180*	0.90801	0.5918			-1.026	0.0002	

FC: ADF tests (T=84, Constant; 5%=-2.90 1%=-3.51)

D-lag	t-ADF	beta	Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
5	-3.369*	0.90103	0.4352	0.1073	0.9148	-1.584		
4	-3.411*	0.90148	0.4324	0.004705	0.9963	-1.608	0.9148	
3	-3.464*	0.90150	0.4297	1.737	0.0864	-1.632	0.9942	
2	-3.267*	0.90640	0.4351	-2.915	0.0046	-1.618	0.4050	
1	-3.695**	0.89120	0.4548	5.136	0.0000	-1.541	0.0288	
0	-2.931*	0.90146	0.5204			-1.283	0.0000	

### ***Unit-root tests – with Trend and Constant***

The sample is: 1992(4) - 2013(3) (90 observations and 2 variables)

iL: ADF tests (T=84, Constant+Trend; 5%=-3.46 1%=-4.07)

D-lag	t-ADF	beta	Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
5	-3.583*	0.85386	0.5138	-0.1087	0.9137	-1.242		
4	-3.729*	0.85285	0.5105	0.6697	0.5050	-1.265	0.9137	
3	-3.689*	0.85920	0.5087	0.4914	0.6245	-1.283	0.7972	
2	-3.687*	0.86323	0.5062	-0.7171	0.4754	-1.304	0.8749	
1	-4.075**	0.85560	0.5047	5.624	0.0000	-1.321	0.8786	
0	-2.878	0.88129	0.5924			-1.012	0.0001	

---

FC: ADF tests (T=84, Constant+Trend; 5%=-3.46 1%=-4.07)

D-lag	t-ADF	beta	Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
5	-3.977*	0.82477	0.4239	0.6550	0.5145	-1.626		
4	-3.963*	0.83266	0.4223	0.5400	0.5908	-1.645	0.5145	
3	-3.983*	0.83883	0.4204	2.180	0.0323	-1.665	0.6994	
2	-3.513*	0.85802	0.4302	-2.400	0.0188	-1.629	0.1549	
1	-4.356**	0.82779	0.4428	5.604	0.0000	-1.583	0.0303	
0	-2.941	0.86564	0.5193			-1.275	0.0000	

*The significance of a deterministic trend in the AR(1) case, as it is most significant:*

**Augmented Dickey-Fuller test for iL; regression of DiL on:**

	Coefficient	Std.Error	t-value
iL_1	-0.14440	0.035435	-4.0750
Constant	1.2200	0.36270	3.3636
Trend	-0.0069634	0.0032945	-2.1137
DiL_1	0.50548	0.089886	5.6235

sigma = 0.504673 DW = 1.98 DW-iL = 0.08866 ADF-iL = -4.075\*\*

Critical values used in ADF test: 5%=-3.463, 1%=-4.07

RSS = 20.37554693 for 4 variables and 84 observations

**Augmented Dickey-Fuller test for FC; regression of DFC on:**

	Coefficient	Std.Error	t-value
FC_1	-0.17221	0.039534	-4.3559
Constant	0.96969	0.27313	3.5502
Trend	-0.0064232	0.0027574	-2.3294
DFC_1	0.50407	0.089946	5.6041

sigma = 0.442829 DW = 1.833 DW-FC = 0.1139 ADF-FC = -4.356\*\*

Critical values used in ADF test: 5%=-3.463, 1%=-4.07

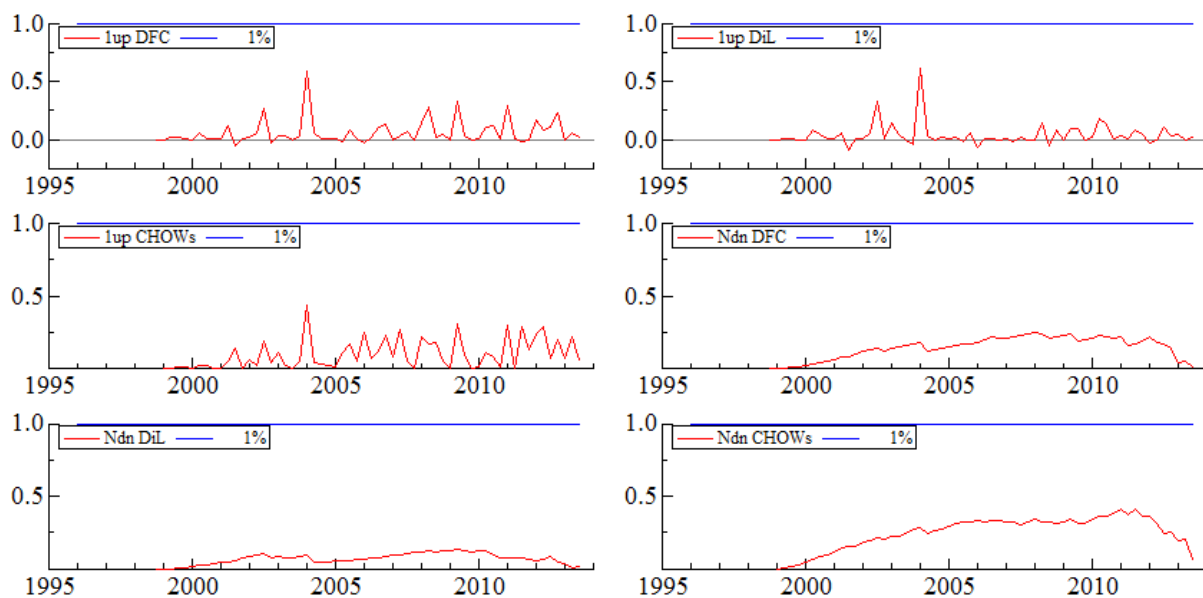
RSS = 15.68783297 for 4 variables and 84 observations

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## Appendix D

### Appendix D.1:

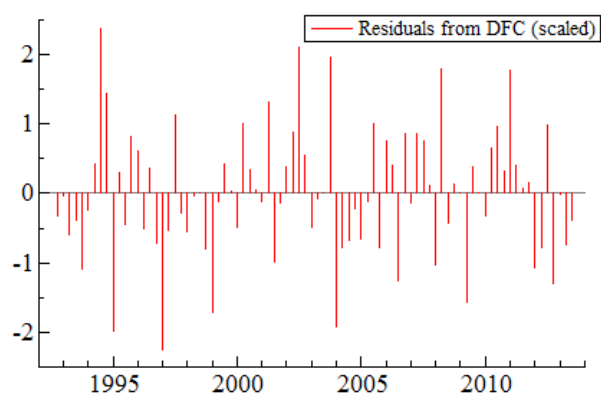
**Figure AD.1: Stability tests based on system in Table 6**



Sample period: 1992Q4-2013Q3

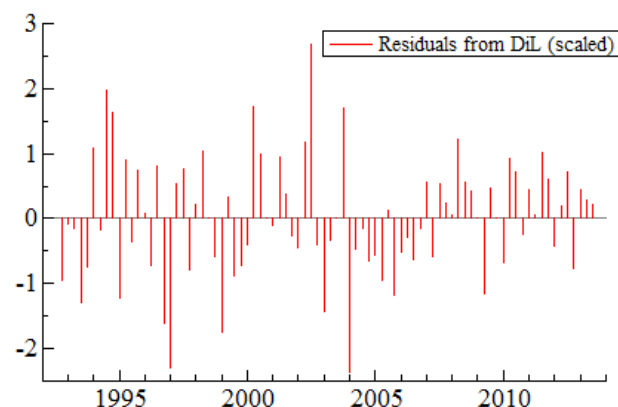
**Figure AD.1.2: Residuals from the estimated equations in Table 6**

*Funding cost residuals (scaled):*



Sample period: 1992Q4-2013Q3

*Lending rate residuals (scaled):*





## Appendix D.2:

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**Table AD.2: The results of estimation with contemporaneous unemployment and original ECM's<sup>32</sup>**

*Sample period: 1992Q4-2013Q3. Both equations were reduced and estimated individually by Robust OLS. The system is estimated using FIML. Dummies excluded for ease of reading (see table 6 in main text).*

*Abbreviations: FC = Funding cost,  $i^L$  = Average lending rate, OG = Output gap, U = Seasonally adjusted unemployment rate<sup>33</sup>, ECM = The error correction mechanisms calculated from Table 6's first lagged level variables.*

***The funding cost equation:***

$$\Delta FC_t = 0.325 - 0.049 \text{ ECM}_{t-1}^{FC} + 0.408 \Delta FC_{t-1} - 0.26 \Delta FC_{t-2} + 0.11 \Delta OG_t - 0.177 \Delta U_t + D + \epsilon_{FC,t}$$

(0.07)    (0.008)                    (0.053)                    (0.05)                    (0.03)                    (0.177)

***The lending rate equation:***

$$\Delta i_t^L = 0.28 - 0.142 \text{ ECM}_{t-1}^{iL} - 0.39 \Delta i_{t-1}^L - 0.07 \Delta i_{t-2}^L + 0.52 \Delta FC_t + D + \epsilon_{FC,t}$$

(0.06)    (0.028)                    (0.05)                    (0.03)                    (0.05)

***System diagnostics***

Vector SEM-AR 1-5 test:  $F(20,118) = 0.56505$  [0.9292]

Vector Normality test:  $\chi^2(4) = 0.65204$  [0.9571]

Vector Hetero test:  $F(66,165) = 1.1675$  [0.2154]

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<sup>32</sup> ECM's might be slightly different than the one expected from Table 6 due to rounding errors and effects of DU.

<sup>33</sup> Seasonally adjusted using PcGive's X12Arima extension (U.S Consensus Bureau, 2011).

## Appendix E

### Data

Most of the data used was retrieved from Norges Bank's *HISTDATA*. Data of the output gap is however, collected from OECD's *StatExtracts*, while the capital adequacy data was, originally, collected from the ORBOF database and forwarded to me from Q. Farooq Akram. Bankruptcy numbers were collected from Statistic Norway's database (SSB), while data for on the wholesale funding share of banks, were collected from Norges Banks' web page. The list below contains a short description of the data and their corresponding abbreviation used in this thesis. Database or source in parenthesis.

**The data - and batch files (Oxmetrics) used in the econometric modelling in this will, as far as possible, be available upon request.**

#### **List of used variables:**

**B** = Number of registered bankruptcies (SSB).

**CAR** = Capital adequacy ratio, i.e. capital to risk-weighted assets. Capital consists of both Tier 1 and Tier 2 capital, where Tier 1 capital is composed of common equity and hybrid equity while Tier 2 capital is additional capital (ORBOF)

**C** = Credit to non-financial firms, mainland Norway. Stock in millions of NOK (HISTDATA).

$i^L$  = Nominal lending rate; Average floating interest rate for bank loans (total) (HISTDATA)

$i^D$  = Nominal deposit rate. Average weighted interest rate (total) (HISTDATA).

**NIBOR** = The 3-months effective nominal money market rate. NIBOR (ask) (HISTDATA).

**NIM** = Calculated using net financial earnings and banks interest earnings assets (SSB)

**OG** = Output gap measured as GDP's percentage deviation from potential GDP (StatExtracts).

**Poil** = Real oil price, USD dollar per barrel (HISTDATA).

**Productivity** = Calculated using gross production and hours worked in the financial sector (SSB)

**WSFS** = Whole sale funding share of banks (Worksheet following Norges Banks' Monetary Policy Rapport with Financial Stability Assessments no. 4, 2013)

**S** = Oslo Stock Exchange All Share Index (HISTDATA).

**U** = Unemployment rate (registered) (HISTDATA).

**Y** = Mainland real GDP of Norway, measured in NOK million at fixed market prices (HISTDATA).